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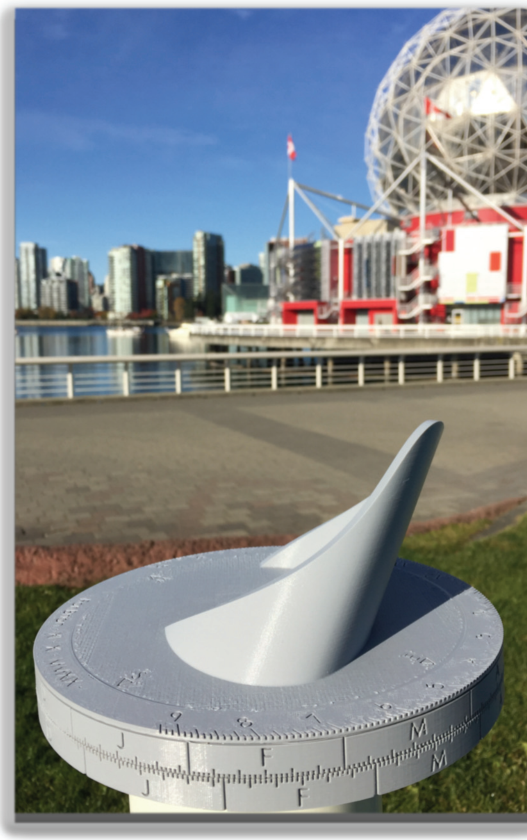
The Compendium*

Journal of the North American Sundial Society



3D-printed Sawyer Polar Envelope Sundial

The shadows are as important as the light.

– Charlotte Brontë (Jane Eyre)

* **Compendium**... "giving the sense and substance of the topic within small compass." In dialing, a compendium is a single instrument incorporating a variety of dial types and ancillary tools.

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Front cover: Sawyer Polar Envelope dial: Concept: F. Sawyer; 3D modelling and photo: Steve Lelievre.
Inside back cover: Horizontal Dial at the Blaylock Mansion, Nelson, BC. NASS Registry #966.

Sundials for Starters: What Makes an Elegant Gnomon?

Robert L. Kellogg (Potomac, MD)

[Items shown thus, #999, refer to NASS registry entries. They can be found using the Search Box on the NASS website, http://www.sundials.org. Ed.]

In the September 2007 Sundials for Starters I talked about "What is a Gnomon?" showing how the polar-aligned shadow caster tells time. More recently, in the Sundials for Starters article of March, 2013, I discussed the visual effect of displacing the gnomon from the center of a horizontal dial and the effect it has on the dial face. As mentioned then, I have a personal preference for dials with gnomons offset by about 40% setback within the chapter ring radius for a most pleasing dial.

Fig. 1. Triangular gnomon from Berkeley, CA.

Regardless of the gnomon's position, we expect the hour angles to radiate out from the toe of the gnomon. In fact, an important test for a properly made horizontal sundial of any latitude, is that a line drawn between 6am to 6pm hour lines should just touch the toe.

Take a look at Fig.1 showing a concrete sundial in Berkeley, CA [#422] with a plain triangular gnomon. This is a reasonable start, especially using the medium of concrete. But there is much more one can do with a gnomon than use a simple triangle. Many large monumental sundials have simple but striking gnomon designs such as Fig. 2 the Lowry 6th Avenue Park sundial [#965] we saw this summer during the annual NASS conference in Denver. The structural element of the gnomon can be embellished as seen in Fig. 3 in another monumental sundial from Grande Prairie, Alberta [#816]. These large gnomons are generally sleek to withstand the side forces of wind and must have counterbalance at the toe. (In fact, if you look closely at the Lowry dial, you can see a red pole support erected perpendicular to the gnomon).

Fig. 2. Sleek Gnomon at Lowry Park, Denver, CO.

Fig. 3. Monumental Gnomon in Grande Prairie, AB.

On a smaller scale many artists have chosen to embellish the area underneath the gnomon. The classic example of this is Paul Manship's distinctive sculptures such his Times and the Fates of Man sundial, Fig. 4, exhibited at the 1939 World's Fair [#247]. Although that plaster sundial was demolished at the end of the fair, it still survives as a 1/8th scale bronze model created by Manship. The 10-foot model gnomon, Fig. 5, is now at Murrell's Inlet, South Carolina [#283]. Manship not only created a graceful sculpture, but through it, told a relevant story: known as Parcae in Roman mythology, and as the Three Fates in Greek mythology, they sit under a tree that holds the sundial gnomon. The goddess of necessity, Themis, brought forth three lovely daughters, Clotho, who spun the thread of life; Lachesis, who measured the thread and determined life direction; and Atropos, who cut the thread of life, causing death.

Fig. 4. Paul Manship Gnomon, 1939 World's Fair.

Fig. 5. Paul Manship's Model at Murrell's Inlet, SC.

Fig. 6. Sundial of Mourning at St. John, NB.

Memorial and remembrance are other significant themes represented in sundials and gnomons. There are more than half a dozen memorial sundials recorded in the NASS sundial registry where the tip of the gnomon's shadow or an illuminating spot of light recognizes the moment of those who died. In this article, I want to focus on the gnomon itself. Fig. 6 of the gnomon at Saint John, NB, [#743] has a gnomon supported by statues of toiling laborers. The dial was dedicated on the Canadian National Day of Mourning, April 28, honoring those workers in Canada who have been killed, injured or disabled on the job. A closer look at the gnomon itself shows the faces of many who died or were injured. In the United States a number of dials such as Fig. 7 from Croton-On-Hudson, NY [#769] used wrecked I-beams from the 9-11 attack on the World Trade Center as a lasting memorial. (One of the hardest problems for these dials was finding I-beams that were straight enough. So hot was the inferno that all the beams found in the debris were severely warped and severed.)

Fig. 7. 9-11 Memorial at Croton-on-Hudson, NY.

Fig. 8 from a sundial at George Washington Memorial Park in New Jersey [#331] decorates the gnomon interior with a bronze statuette in the shape of a griffin taken from Washington's coat of arms. The sundial at Lowell Observatory, Fig. 9, in Flagstaff, AZ [#002], a gift from the staff to Percival Lowell, likewise shows a griffin to denote strength, courage and leadership.

Fig. 8. George Washington Coat of Arms, Paramus, NJ.

Sundials in the shape of statuary are common, but it is the true artist who can integrate the gnomon successfully into the artwork. Fig. 10 from Oakland, CA [#307] and Fig. 11 from St. Louis, MO [#354] show two unique ways of making the gnomon a functional part of the sculpture. And Fig. 12 is a simple trope from Boston, MA [#280] that we all recognize. Regarding this last sundial, it seems to have gone missing during remodeling. It may now be located on the roof-top garden of the Children's Hospital Medical Center. Hopefully the bird is still catching the worm.

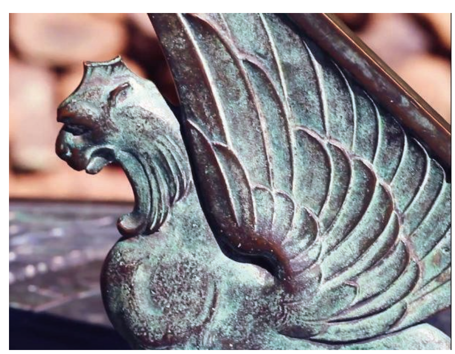

Fig. 9. Staff Gift Sundial for Percival Lowell at Flagstaff, AZ.

Fig. 10. Archer at Children's Hospital in Oakland, CA.

Fig. 11. Child Playing with a Sundial, Missouri Botanical Garden.

Fig. 12. Early Bird Catches the Worm, Children's Hospital Boston, MA.

Fig. 13. The Bird of Time Sundial, Albuquerque, NM.

I am partial to the sundialist Gino Schiavone who has created a number of beautiful sundials with distinctive gnomons. Fig. 13 is his dial in Albuquerque, NM [#669] with a gnomon of subtle significance. The gnomon shows a resting and a flying bird against a background of a bronze tree. The bird motif reminds the viewer of the lines of the poem "The Bird of Time has but a little way to fly -- and Lo! the bird is on the Wing" by Omar Khayyam. For a moment, let me continue on the gnomon theme of birds with two dials by dialist and artist Cecilia Lueza. Fig. 14 is a sundial gnomon showing a flight of birds from her work in the District of Columbia [#850] entitled "Time Flies" and Fig. 15 (taking license with the requirement of a straight gnomon edge) is an 8-foot tall humming bird sundial in Peoria, AZ [#939].

I can't leave the design of gnomons without showing two gnomons of pure whimsy. Fig. 16 in Gold Canyon, AZ [#657] is of a howling coyote that perfectly matches the desert environment even if accurate time is never achieved. And Fig. 17 from a nudist park in Roselawn, IN [#971] is cheeky and totally inaccurate. But how can one complain since it is located at the Sun Aura Resort?

Bob Kellogg *rkellogg@comcast.net*

[Figures continue on the next page]

Fig. 14. Time Flies, District of Columbia.

Fig. 15. Hummingbird in Peoria, AZ.

Fig. 16. Howling Coyote at Gold Canyon, AZ.

Fig. 17. Leggy Gnomon at Sun Aura Resort, Roselawn, IN.

Polar Envelope Gnomons

Fred Sawyer (Manchester CT)

Background

The task of adjusting a horizontal sundial to account for the equation of time would be much easier if the shadow of the gnomon progressed across the dial face at a uniform rate; however, as we all know, it does not. Over the years, I have discussed various techniques for addressing this issue. As examples, two dials of my own design include the Equant,[1] which uses a special curve to convert the non-uniform progression of the shadow to a reading on a uniform time scale, and the Foster-Point,[2] which reflects the shadow's intersection with a circle through a particular point on the circle's diameter to indicate the time on a uniform 12-hour scale on the opposite side of the circle. Once the time is indicated on a uniform circular scale, it is easy to rotate that scale each day to change the reading from apparent solar time to local mean time.

A third design, which I have also discussed in some depth,[3] is the Foster-Lambert sundial, invented in the 17th century by Samuel Foster and again independently in the 18th by J.H. Lambert. This dial is similar to an analemmatic, but it uses a sloped gnomon to change the usual elliptical hour ring into a circular ring with an equispaced time scale.

Recently, Steve Lelievre asked me to evaluate a Foster-Lambert dial he had designed using a 3-D printer. Because the printing process required that the dial have a rather wide gnomon, Steve had used a sloped cylinder but had modified the horizontal cross-section in the hope that he could legitimately read time from the intersection of the circular hour ring and the leading or trailing edge of the wide gnomon's similarly wide shadow. I provided him with an analysis that showed the error in this approach but also allowed Steve to keep the error to less than 30 seconds of time in almost all cases.[4]

This project led, as all good projects do, to yet another challenge. Given the flexibility and facility provided by a 3-D printer, is it possible to design a horizontal dial with a wide polar-oriented gnomon whose shadow, or at least one edge of the shadow (leading or trailing), passes over equal arcs of a circular hour ring in equal times? After some thought, I determined that such a design is indeed possible for a wide range of latitudes.

Design Development

Begin with a circular hour ring with hours marked at equal intervals, which we will set for now at 15°/*hr*. Move the noon point away from the north-south diameter by an angle *a*, because with a wide gnomon we know that a noon point on the diameter would be surrounded in shadow rather than being touched by a leading or trailing edge of shadow. The angle from north as measured from the center to any hour point *t* will be $a + bt$, where *a* is to be selected and *b* is currently set equal to 1. See Figure 1, where we have set the latitude equal to 41.8° and angle *a* to 37°. (To avoid confusion, note that we have oriented the circle so

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[1] *An Equant Sundial*, Bulletin of the British Sundial Society, Jul 1991, 91(2):34. *Yabashi Point and Sawyer Equant*, The Compendium, Dec 2000, 7(4):27-29. *A Self-Orienting Latitude Independent Analemmatic Equant Dial Design*, The Compendium, Dec 2003, 10(4):7-10. *A Bipolar Azimuthal Equant Sundial*, The Compendium, Jun 2005, 12(2):13-16+addendum. *Linear Equant Sundial Design*, The Compendium, Sep 2016, 23(3):21-26.

[2] *The Foster-Point Sundial: Time In A Perfect Round*, The Compendium, Sep 2001, 8(3):14-16. Reprinted in Bulletin of the British Sundial Society, Mar 2002, 14(i):9-11. *Regulating the Foster-Point*, The Compendium, Dec 2001, 8(4):7-9.

[3] *A Self-Orienting Equiangular Sundial*, Bulletin of the British Sundial Society, Oct 1991, 91(3):24-25. *Samuel Foster of Gresham College*, Bulletin of the British Sundial Society, Jan 1997, 97(1):2-15. *Elliptical Sundials: General & Craticular*, The Compendium, Dec 2016, 23(4):25-35.

[4] For more details on this project, see Steve Lelievre's Power Point file *A Wide Gnomon Foster-Lambert Dial*, included as a digital bonus in The Compendium, Sep 2019, 26(3).

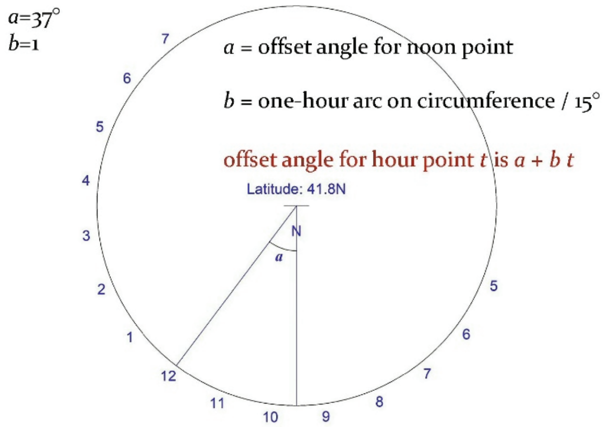


Figure 1.

that North is to the bottom.) From each of the hour marks, draw a line into the circle at an angle θ from vertical equal to the angle for a traditional hour line – so $\tan\theta = \tan t \sin\varphi$. For noon, the line is vertical from 12. Each of the other hour lines is as indicated in Figure 2.

If we place a traditional polar-oriented gnomon at the point where the 12 and 11 lines meet, its shadow will indicate the correct time at 12 and 11 but will not work very well for other times. Another such gnomon placed at the intersection of the 11 and 10 lines will work well at 11 and 10, but not other times. Note that we have a whole string of these intersections. Suppose we drew lines for all times of the day – not just the whole hours – and placed a gnomon at each intersection point. Each gnomon, at its appointed time, would cast a shadow on its appointed hour mark, and all the hour marks are distributed at uniform spacing around the time circle. The shadows of all the gnomons would coalesce into one wide shadow whose leading edge

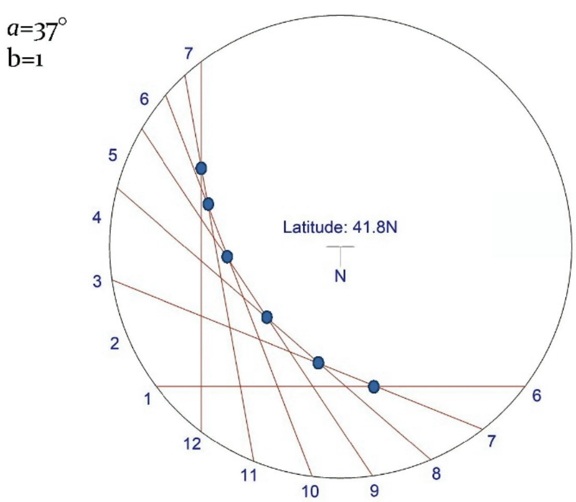


Figure 2.

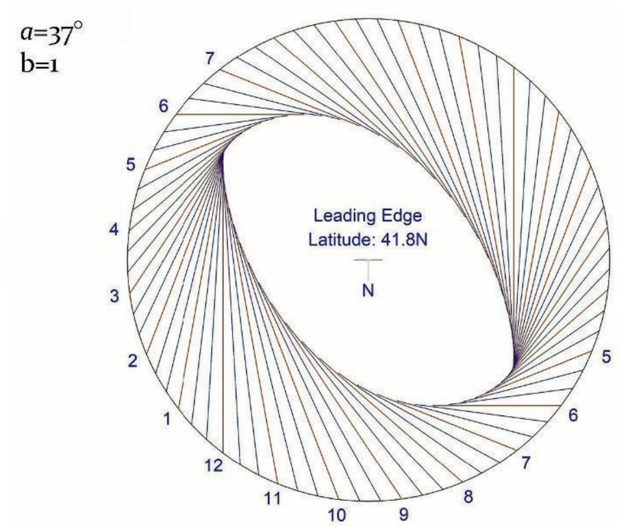


Figure 3.

at the appropriate times would appear as the lines in Figure 3 with each of these lines clearly a tangent to a closed convex area. If we can determine the equation of the boundary curve for this closed area, we will have the horizontal cross-section of a wide gnomon which, if it rises from each point on the curve at an angle equal to the dial's latitude, will cast a shadow whose leading edge will pass through equal arcs on the hour circle in equal times.

Envelope

So, how do we determine the equation for what clearly appears to be a curve formed by the intersections of all these lines? The lines can be described by the equation $y = \dfrac{x}{\tan t \sin\varphi} - r\dfrac{\sin(a+bt)}{\tan t \sin\varphi} + r\cos(a+bt)$, which defines what may be called a one-parameter family of lines, with t being the parameter that distinguishes one line from another. Values of a and b are as specified earlier; r is the radius of the hour circle, and φ is the latitude. The curve defined by the intersections of these lines can be found by setting the partial derivatives (with respect to the parameter t) of each of the coordinates x and y equal to 0. The result of this operation yields the following parametric equations of the curve:

$$\boxed{\begin{aligned} &x = r\left[k(t)\sin t - \sin(a+bt)\right] \qquad y = r\left[k(t)\frac{\cos t}{\sin\varphi} - \cos(a+bt)\right], \\ &\textit{where} \quad k(t) = b\left[\cos t\cos(a+bt) + \sin\varphi\sin t\sin(a+bt)\right] \end{aligned}}$$

This curve is known as the *envelope* of the family of lines. If we let it serve as the horizontal cross-section of a wide polar-oriented gnomon, we have what I have called a *polar envelope gnomon*.

<u>Variations</u>

Now that we know how to define the gnomon in such a way that can be handled by a 3-D printer, let us consider what happens when we try varying the values of the constants.

At our given latitude of 41.8˚, we already know that if a = 37˚ and b = 1, we have a gnomon whose leading edge indicates the time with hour markers spaced at 15˚/*hr*. Note that the latitude and a have the same sign; if we use opposite signs, so φ = 41.8˚ and a = -37˚, the resulting gnomon continues to function, but time is now indicated by the *trailing* edge of the gnomon's shadow. See Figure 4.

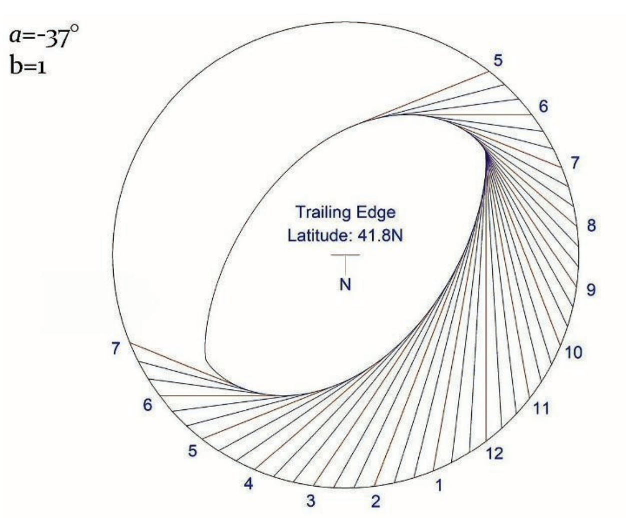


Figure 4.

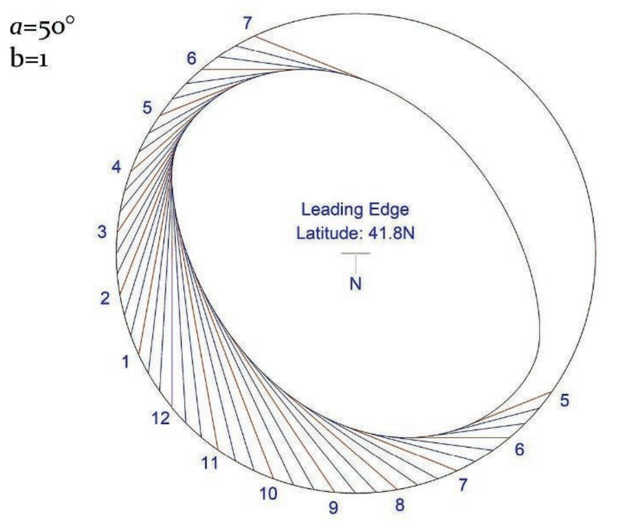


Figure 5.

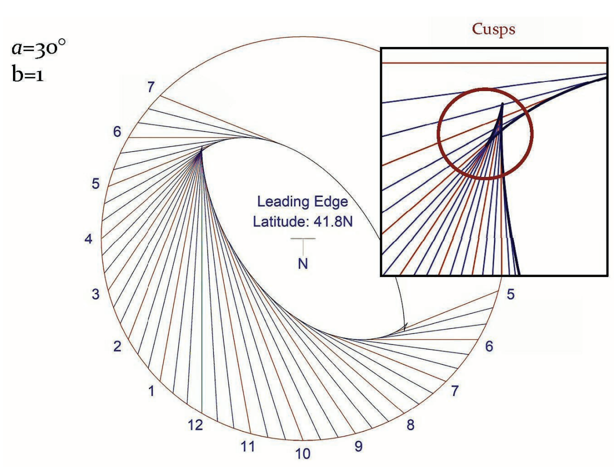


Figure 6

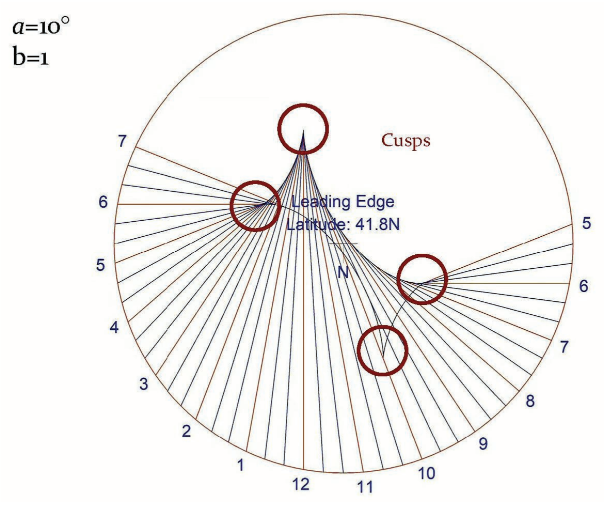


Figure 7

Return now to the leading-edge configuration and consider what happens if we increase the value of a. The gnomon's cross-section becomes a bit more rounded and much larger. See Figure 5. In order to leave some room on the dial face and to have a less massive gnomon, we need to consider lower values of a.

In Figure 6, we see the result of setting $a = 30^\circ$ at this same latitude. Initially, the cross-section area may look fine, but notice the close-up shot. The two extreme ends of the curve have sprouted cusps – where the curve turns back on itself and ruins our chances of using it for a gnomon. To see how pronounced this effect can get, look at Figure 7 with $a = 10^\circ$; here we have totally lost the convex nature of the curve. So, for this latitude, it turns out, through inspection, that we need to use a value $a > 36.8907^\circ$ to avoid the cusps. Even with this minimum value, the curve will have what is known as a singularity, where the two sides of the curve seem to come together in a sharp point but do not cross each other. The table below gives the minimum whole degree value of a to avoid cusps at latitudes from 30˚ to 89˚.

Lat.	Min. |a|	Lat.	Min. |a|	Lat.	Min. |a|	Lat.	Min. |a|	Lat.	Min. |a|	Lat.	Min. |a|
30˚	-	40˚	41˚	50˚	24˚	60˚	13˚	70˚	6˚	80˚	2˚
31˚	-	41˚	39˚	51˚	23˚	61˚	12˚	71˚	5˚	81˚	2˚
32˚	68˚	42˚	37˚	52˚	21˚	62˚	11˚	72˚	5˚	82˚	0˚
33˚	63˚	43˚	35˚	53˚	20˚	63˚	10˚	73˚	4˚	83˚	0˚
34˚	59˚	44˚	33˚	54˚	19˚	64˚	10˚	74˚	4˚	84˚	0˚
35˚	55˚	45˚	31˚	55˚	18˚	65˚	9˚	75˚	3˚	85˚	0˚
36˚	51˚	46˚	30˚	56˚	17˚	66˚	8˚	76˚	3˚	86˚	0˚
37˚	49˚	47˚	28˚	57˚	16˚	67˚	8˚	77˚	3˚	87˚	0˚
38˚	46˚	48˚	27˚	58˚	15˚	68˚	7˚	78˚	2˚	88˚	0˚
39˚	44˚	49˚	25˚	59˚	14˚	69˚	6˚	79˚	2˚	89˚	0˚

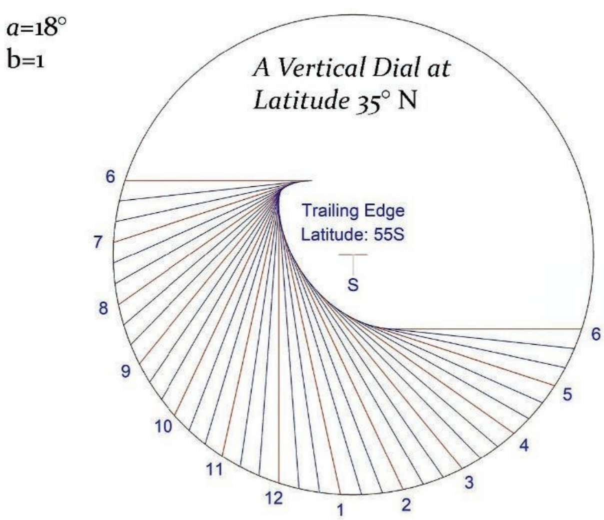


Figure 8

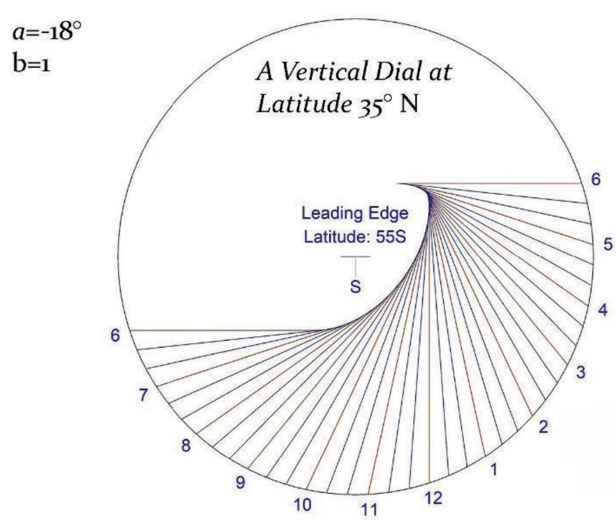


Figure 9

Obviously, as we consider latitudes closer to the equator, we obtain gnomons that become less convenient. We have a few options to consider. We can either use an alternative design, one of those we will discuss below, or we can do what is often done in this geographic region – use a non-horizontal plane. For example, at latitude 35˚N, we can construct a vertical direct south dial using the design for a horizontal dial at latitude 55˚S. And in doing this, we can select either a leading-edge or a trailing-edge gnomon. See Figures 8 and 9 (In these images we have not shown the whole cross-section for the gnomon; we have shown only the functional portions needed for the dials to function during the hours they are in sunlight.)

Gnomon Height

If we now actually build a dial with a polar envelope gnomon (Thank you, Steve!), it quickly becomes apparent that it is necessary to have the gnomon's height be at least large enough to assure that its shadow always reaches to the hour ring. In most horizontal dials, it suffices to determine the gnomon height that will produce a shadow at noon on the summer solstice that reaches the hour ring; however that strategy will not work here, because the root of the gnomon that effectively casts the shadow on this dial is not at the dial center – it moves all around the envelope curve.

So, we calculate a minimum height needed at every time *t* on the summer solstice – not just noon. Each point on the envelope curve corresponds to a particular time *t* and serves at that time as the root of the gnomon casting its shadow on the hour mark for *t*. To find the height $h(t)$ associated with time *t* (*i.e.* vertical height, not the length of the gnomon): (*See the addendum to this article for a derivation of this equation.*)

$$h(t)=\begin{cases} rb\cos a\dfrac{\cos(\varphi-\varepsilon)}{\cos\varepsilon}, & \text{if } t=0^\circ \\ r\tan\varphi\dfrac{\sin(z-\theta)}{\sin z}\sqrt{\sin^2 t+\cos^2 t/\sin^2\varphi}\; k(t), & \text{if } t\neq 0^\circ \end{cases} \qquad \varepsilon=\pm 23.44^\circ \ \text{ use same sign as } \varphi$$

$$z=\tan^{-1}\frac{\sin t}{\cos t\sin\varphi-\cos\varphi\tan\varepsilon} \qquad \theta=\tan^{-1}(\tan t\sin\varphi) \qquad z \text{ and } \theta \text{ have the same sign as } t$$

$$k(t)=b\left[\cos t\cos(a+bt)+\sin\varphi\sin t\sin(a+bt)\right]$$

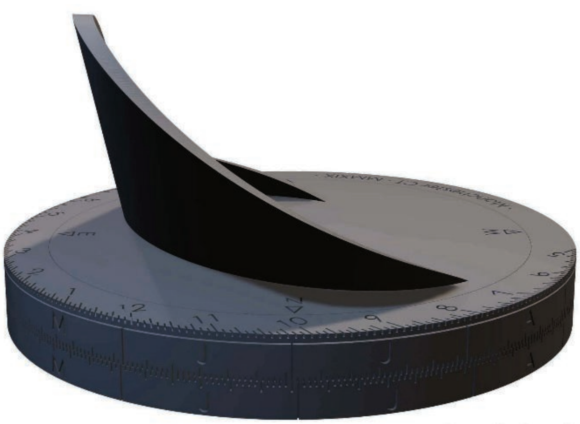
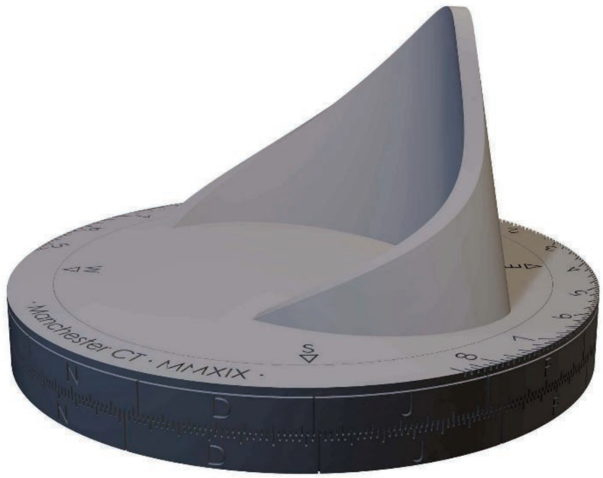


Figure 10 Viewed from North (Images by Steve Lelievre) Figure 11 Viewed from East

The resulting gnomon and sundial (Figures 10-13) have an aesthetic sculptural look that comes directly from the equations. The configuration pictured here uses the leading-edge of the gnomon's shadow to indicate the time. If we prefer instead to read the time from the trailing-edge of the shadow, we need merely negate the value of the constant *a* in the equations before starting the printer.



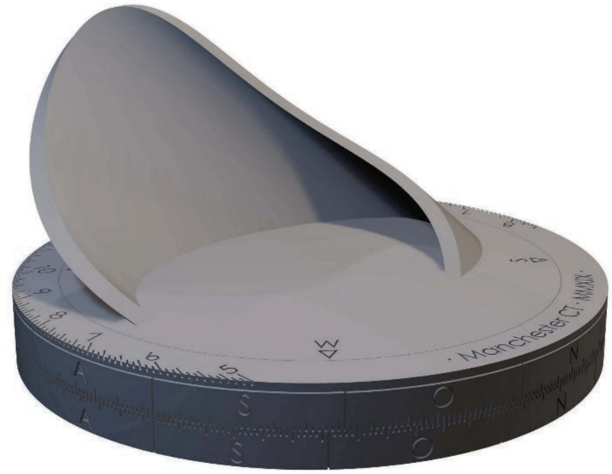


Figure 12 Viewed from South (Images by Steve Lelievre) Figure 13 Viewed from West

<u>Double Edge Configuration</u>

Having considered both leading and trailing-edge options, we are now faced with the challenge of designing a gnomon that can indicate time using both edges of its shadow at the same time. This task requires some playing with the equations. The solution I found is to set $b = 1/\sin|\varphi|$ and $|a| = 3.75^\circ bn$, where n is an odd integer (I chose $n = 9$); this will work for high latitudes: $|\varphi| > 47.52^\circ$.

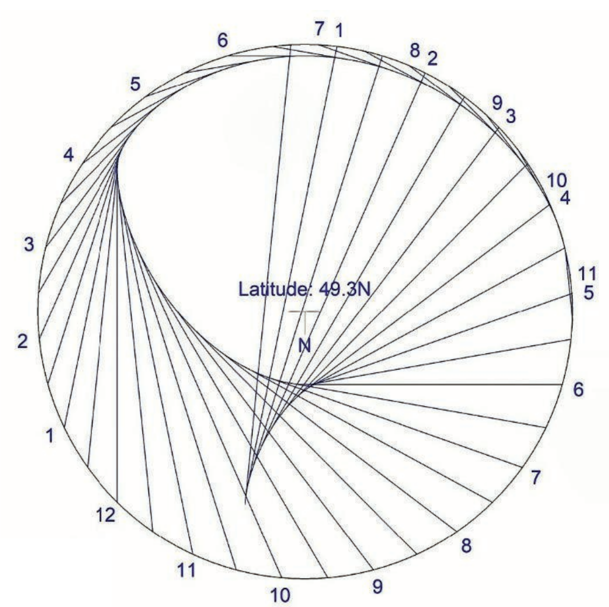


Figure 14.

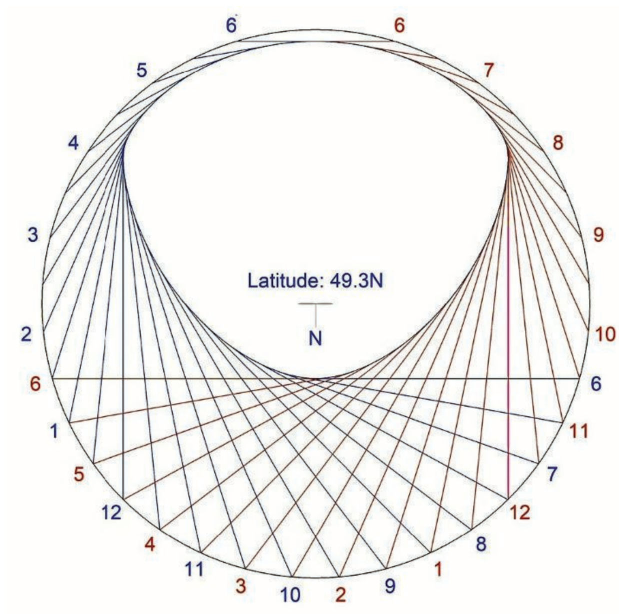


Figure 15.

At first inspection, this setup does not look as though it can produce a usable gnomon (Figure 14). Note, however, that the selection of the value for b assures that the entire 12 hour section of the gnomon's leading edge from 6am to 6pm lies on one side of the meridian line. If we use only that section of the curve and then draw a mirror image of it, reflected through the meridian line, we obtain the two sets of hour lines shown in Figure 15. Our selection of the value for a assures us that the entire width of the gnomon's shadow is always equal to $n/2$ hours as measured on the circumference; in the case illustrated, with $n = 9$, the shadow takes up exactly 4.5 hours spacing on the hour circle. Therefore, both edges progress around the hour circle at a uniform rate (equal to $15^\circ b/hr$, which in this case at latitude 49.3° equals $19.79^\circ/hr$). By selecting n as an odd integer, we obtain a shadow width that results in leading and trailing edge scales such that the whole hour marks on the two scales interleave nicely and the numbering does not look too crowded. See Figure 16.

Figure 16. Throughout the day, the shadow intersects the same length arc on the hour circle. Time can be read from either edge of the shadow. Blue numerals, leading edge; Red numerals, trailing edge.

Given that a double edge reading can be had for 12 hours of the day, it is tempting to wonder if that range of hours can be extended. Unfortunately, as can be seen in Figure 17, the hour line that would be required for, say, 4am cannot be tangent to the gnomon's cross-section. If we restore the original curve (Figure 18), we see that the 4am hour line is tangent to the curve on the cusp that we had to eliminate early in the procedure. So, 6am to 6pm will have to suffice.

<u>Alternating Edge Configuration</u>

The family of curves we obtain by changing the values of *a* and *b* is very interesting and probably deserves more study. Let us consider just one more configuration. We have seen that it is possible to use both edges of the shadow to read the time, but what sort of gnomon results if we ask simply to use alternating edges – say, the leading edge in the morning and the trailing edge in the afternoon.

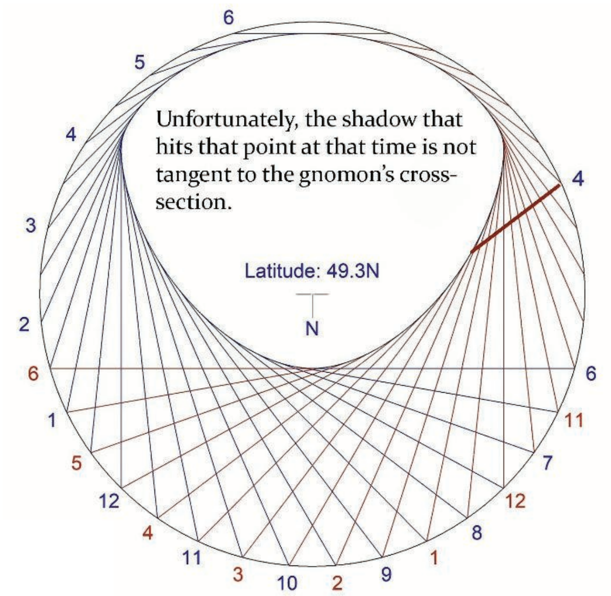


Figure 17

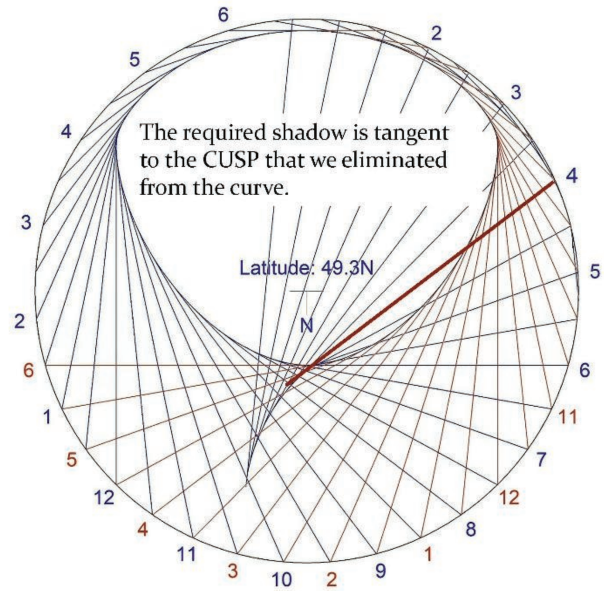


Figure 18

Once again, the investigation requires some playing with the equations.

The solution I can suggest has the drawback of reducing the space allowed on the hour circle for each hour, but it opens possibilities for sundials at lower latitudes than the earlier configurations.

Let $b = 2/3$, so the hour scale will allocate $10°/hr$. And let $a = 90°b$, so in this case, $a = 60°$. At latitude 20°, the resulting curve, almost completely restricted to the east half of the dial, is as shown in Figure 19. Note that everything looks fine in the morning, but a cusp develops at noon. So, we will get rid of the curve after noon.

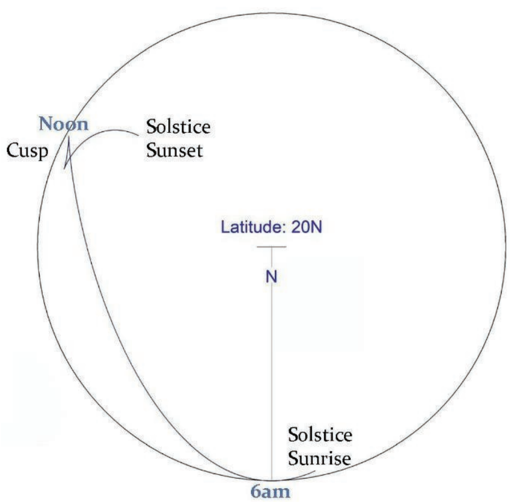


Figure 19

If we recreate the curve but negate the value of a, we get a similar situation on the west side of the dial. The east side curve works with the leading edge of the shadow, and the west side curve makes use of the trailing edge. To avoid

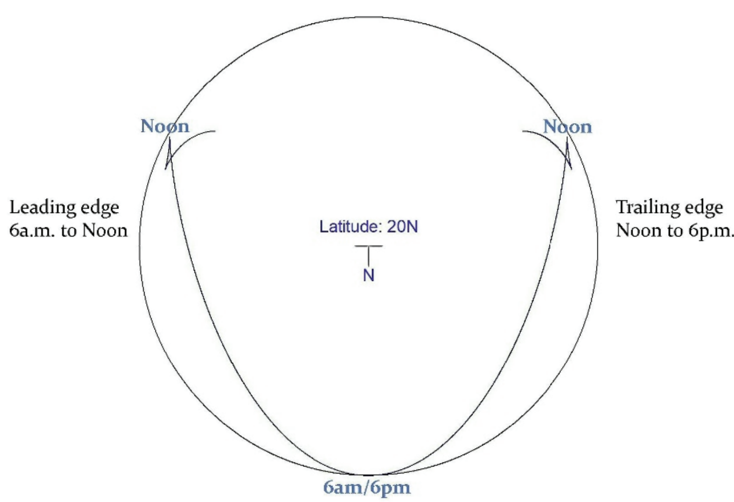


Figure 20

overlapping, we use only the portions of the curves after 6am and before 6pm, and we clip both curves at noon to eliminate the cusps. The resulting combination of the two curves is convex, but not closed. But that poses no problem, because what we have functions for the required 12 hours each day. See Figure 21.

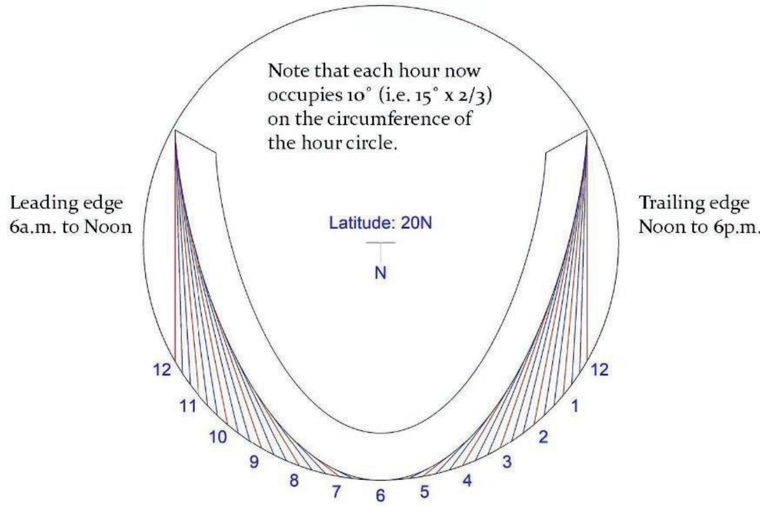
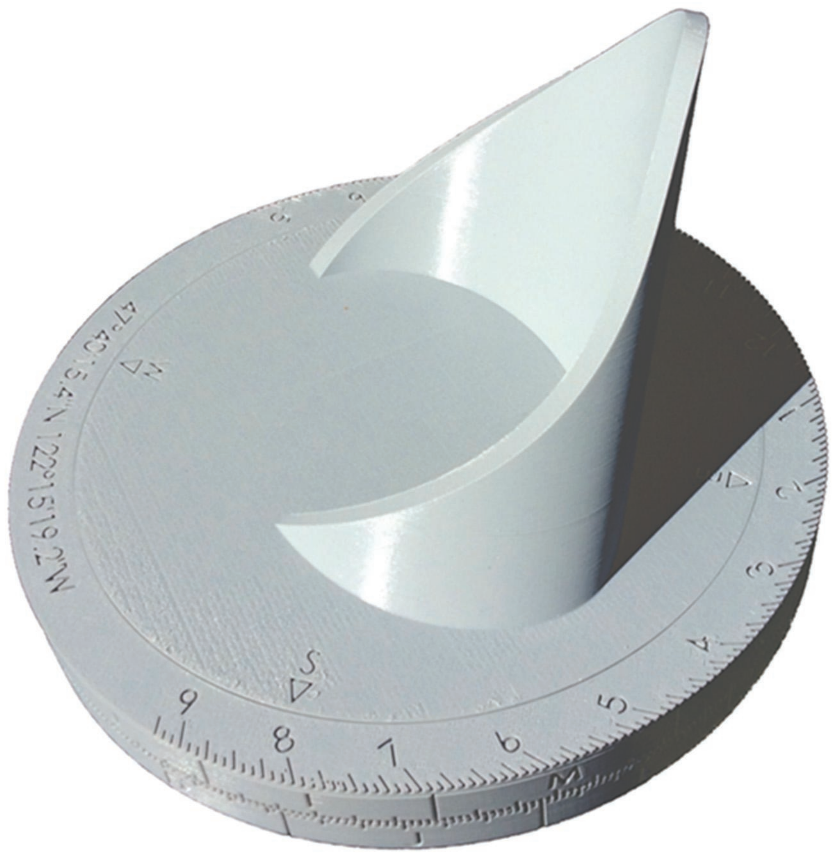


Figure 21



Dial with Polar Envelope Gnomon. Design: F. Sawyer; 3D printing: S. Lelievre; photo: Art Kaufman.

Thanks to Steve Lelievre for asking the initial question and for turning the equations into 3-D images and objects.

Addendum – Derivation of the equation for gnomon height

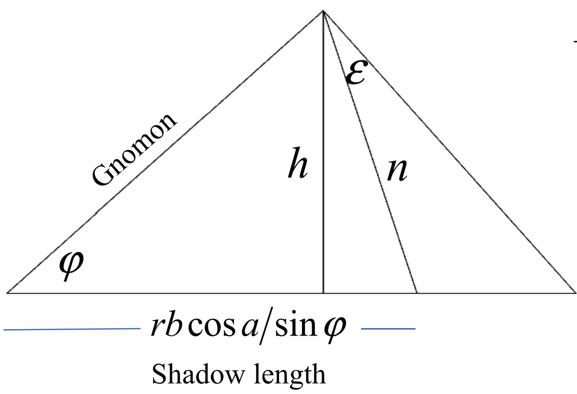
At any given time, the wide gnomon may be viewed as a single thin rod with its root at

$$x = r\left[k(t)\sin t - \sin(a+bt)\right] \qquad y = r\left[k(t)\frac{\cos t}{\sin\varphi} - \cos(a+bt)\right],$$

$$\textit{where} \quad k(t) = b\left[\cos t\cos(a+bt) + \sin\varphi\sin t\sin(a+bt)\right]$$

and its shadow must reach at least to the point $x = -r\sin(a+bt)$ $\;y = -r\cos(a+bt)$ on the hour circle. So, the minimum length of the shadow must be $L = r\sqrt{\sin^2 t + \cos^2 t/\sin^2\varphi}\;k(t)$, the distance between these points.

At noon, we have $t = 0^\circ$, $k(t) = b\cos a$ and $L = rb\cos a/\sin\varphi$. This diagram shows the relationship of the gnomon and shadow in the meridian plane. Simple right-triangle trigonometry gives us:



$$\frac{n}{\sin\varphi} = \frac{rb\cos a/\sin\varphi}{\sin\left(90^\circ - \varepsilon\right)} \qquad \Rightarrow \quad h = rb\cos a\frac{\cos(\varphi-\varepsilon)}{\cos\varepsilon}$$

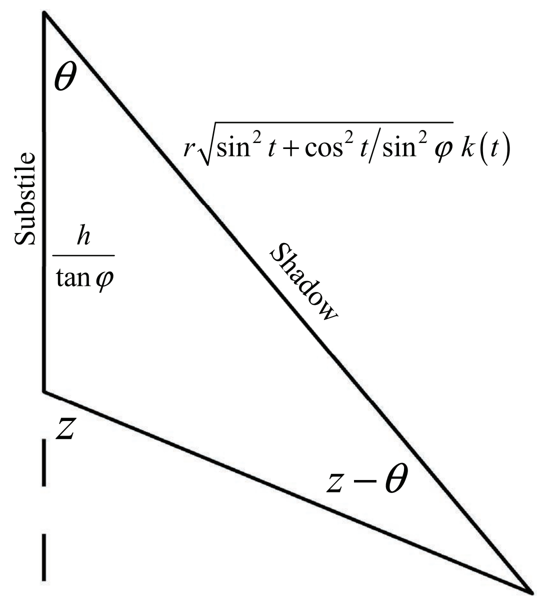
$$h = n\cos(\varphi - \varepsilon)$$

Consider now the case in which $t \neq 0^\circ$. This triangle is in the horizontal plane. We have equations for the hour line angle θ and for the solar azimuth z.

$$z = \tan^{-1}\frac{\sin t}{\cos t\sin\varphi - \cos\varphi\tan\varepsilon} \qquad \theta = \tan^{-1}(\tan t\sin\varphi)$$

From the diagram and the sine law of trigonometry, we see that:

$$h = r\tan\varphi\frac{\sin(z-\theta)}{\sin z}\sqrt{\sin^2 t + \cos^2 t/\sin^2\varphi}\;k(t)$$



A PowerPoint file on the development of the Polar Envelope Gnomons is included with this issue as a digital bonus. It was the basis of the author's talk at the 2019 NASS Conference in Denver CO.

Fred Sawyer *fwsawyer@aya.yale.edu*

The Honey Bee Haven dial - an analemmatic sundial using ceramics

Rick Williams (Woodland, CA)

The art and science of ceramics, like sundials, date to ancient times and have generated much knowledge. Being both a novice ceramicist and dialist, I can claim no expertise in either, and I am confident that inaccuracies in the following will be found by many, but I have learned along the way.

Ceramic tiles, when fired at high temperatures, are very durable, and can handle decades of foot traffic. They can be decorated with colorful glazes and designs. The main disadvantage is that large tiles often warp when drying and all tiles shrink when fired in the kiln, and production takes time.

I wanted to construct an analemmatic sundial at the Honey Bee Haven, a small garden at the University of California, Davis (38° 32′ N), dedicated to promoting awareness of native pollinating insects as well as the familiar introduced honey bee. I was daunted by plans using concrete or mosaics, and wanted something flashier than painted commercial tiles. With the help of my wife, who *is* a ceramicist, I did it along the following lines.

Since we do not own a kiln, I used a local ceramics studio. Hopefully there is one in your area, and they will advise you on the clays and glazes that are available.

I computed the dimensions for the sundial using the web page "Analemmatic sundials: how to build one" at https://plus.maths.org/content/analemmatic-sundials-how-build-one-and-why-they-work. I computed the shadows for a person (i.e. gnomon) of height 6 ft, for the winter (11.8 ft) and summer (1.6 ft) solstices, and used an ellipse with a semi-minor axis of 5 ft and a semi-major axis of 8 ft. This required a declination scale length (December - June solstice distance) of 5.4 ft.

I used Cone 5-6 Sculpture Raku clay. The term *cone* is a traditional measure of the firing temperature. Cone 5-6 indicates the material is intended to be fired at 2100-2200°F. Raku clay has a higher that usual percentage of "grog" (silica and alumina), which makes it less likely to crack at high temperatures.

As well, this type of clay is plastic, meaning it is flexible and can be molded, and will retain that shape and, when fired to Cone 5, is impervious to water and has great strength.

Clay must be "wedged", which involves using a special kneading method to remove trapped air so that the item does not crack or break in the kiln. I never got the hang of this, and after my wife wearied of doing it for me, I found it was easier to use the clay right out of a 20 lb. bag, which is sold in blocks, and is already wedged.

Depending on the size of the tile, which ranged from 14″ × 11″ to 0.6″ × 11″, I sliced off an appropriate amount of clay using piano wire, and then rolled it out. A commercial slab roller would have made this much easier, but I did not have access to one - so I rolled the tiles out with a 3½″ diameter PVC pipe and two wooden slats ½″ high on each side to insure the proper height (Fig. 1). The larger tiles were quite a workout.

Fig. 1. Rolling out the tiles

Sculpture Raku has a shrinkage rate of 6-10%; the higher the firing temperature, the more shrinkage. I started with one tile at 110% of the desired final dimensions, and after firing, found the actual shrinkage rate corresponded to using 106.7% for the unfired size. This remained constant, to my surprise, for all sizes of tiles and all bags of clay. I made cardboard templates with 106.7% dimensions and then laid these over the clay so I could cut the tiles exactly. In the end, there was only 2 - 3 mm difference in the actual to planned dimensions over the 65″ walkway span.

Drying the tiles took time and practice. After cutting a tile, I would keep it covered with plastic wrap and weighted down by a few heavy books in between two ½″ thick drywall boards. Clay has a “memory” of its former shape and takes time to adapt to a new form; you can’t rush it. After a week or so I would begin to uncover the plastic for 1-2 hours a day, keeping the plastic wrap around the edges. Whatever is done to one side must be exactly reproduced by flipping the tile and drying the other side for an equal amount of time. When I was less than meticulous about this I would eventually wind up with a warped tile. Painting the edges of large tiles with a water-resistant wax coating would keep the corners from drying too quickly. After 10 -14 days, the drying time could be extended to 3 - 4 hours a day, and then the plastic could be removed and the dry wall board would absorb additional moisture. After a few more days, the clay would become “leather-hard”, at which time numbers and letters could be cut into the tiles.

Lacking all artistic talent, I made stencils by cutting out paper numbers and letters. I used a photocopier’s magnification feature to attain outlines of the proper size. I wanted a font fancier than just block letters, but not as busy as gothic lettering, and settled on the “Georgia” font[1]. I traced the letters around the stencil with a craft knife and then scooped out the letters with a small clay scoop-like tool so I had 2 mm depth for a nice contrast.

After another week or so, the tiles could be given a colorful underglaze, using colors of the prism, and the letters or numbers painted with black underglaze. At least three coats should be applied for vibrant colors. The tiles were then “bisque” fired to 1800 degrees F. After this, a black “Stroke and Coat” glaze was applied to the recessed letters and numbers to give a shiny appearance, and a clear glaze applied overall. The second firing was then performed up to 2100 degrees F. I made the numbered hour tiles 4″ × 4″ and thinner (3/8 inch) than the month tiles.

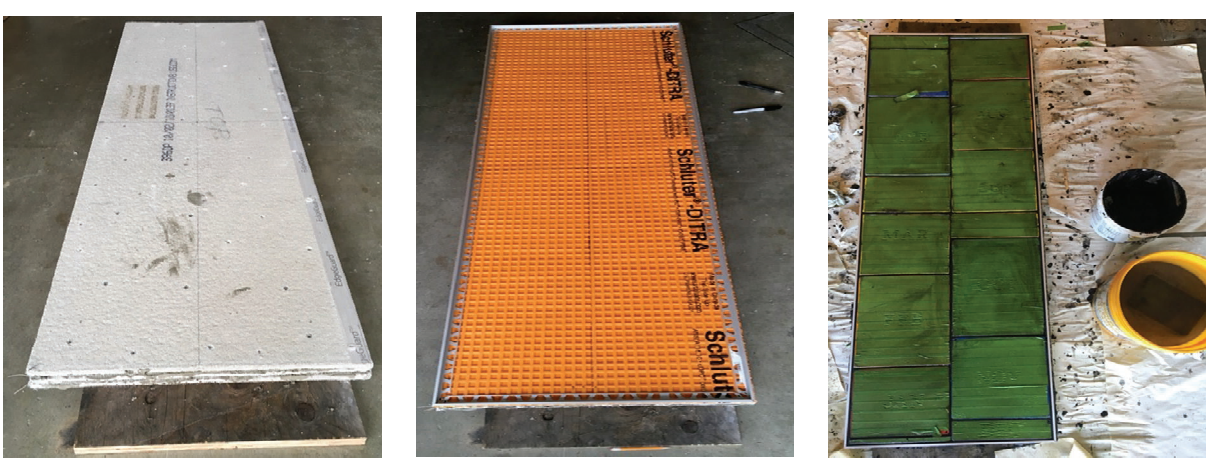


Fig. 2: Making the declination scale: (a, left) Cement board stacked in 3 layers, mortared and screwed; (b, middle) Orange Ditra uncoupling membrane and aluminum trim in place; (c, right) tiles laid in, with green painter’s tape as protection and black epoxy applied as a grout.

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[1] I thought this was an older, Victorian-looking font which must have been around for a while. It actually was developed in 1993 by Microsoft. It was named “Georgia” because the creator, Matthew Carter, had a tabloid magazine lying around with a front-page headline “Alien heads found in Georgia.”

The tiles were then mounted on substrate. The garden has walkways of decomposed granite, so I wanted a firm base. I found Durock ½″ cement board that could be purchased in 4 x 8 ft sheets, so I did not have any seams for the length of the declination scale, and cut and stacked up three sheets. I applied Schluter "All set" mortar, which is a modified mortar better suited for outdoor use, to bond the layers, and liberally used cement board screws on both sides. This gave over 1½ inches of seamless, solid cement board on which to place the tile (Fig 2a).

The ground moves, especially in California. Additionally, cement board's thermal expansion and contraction rates differ from ceramic tile. Stresses from the ground substrate are thus transmitted to overlying tile, eventually causing cracks and possible buckling. For centuries, tile-layers have solved this by "uncoupling" the tile from the substrate by using a layer of sand or a "mud bed" in between to absorb energy. The Schluter company makes "Ditra," a waffle-patterned plastic membrane which accomplishes the same thing. This was affixed to the cement board base with All Set mortar (Fig. 2b). Aluminum trim, also made by Schluter in many heights and designs, gave the tiles a border which protected their edges and accentuated the walkway. The tiles were then set onto the Ditra membrane with mortar.

Cementitious grout, unlike the tiles, is permeable to water and is not as durable. Therefore, with some trepidation, I used epoxy grout, which is harder to work with and clean up, but gives a very durable grout to stand up to the rigors and temperature fluctuations of an outdoor application.

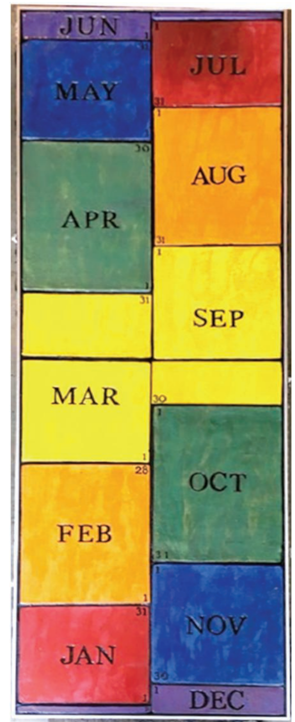

Fig. 3. Tape removed and tiles cleaned.

I used CEG-Lite commercial epoxy grout, which comes in many colors, including the jet black that I chose. Knowing that the recessed letters would collect the grout and be very difficult to clean, I used painter's tape to tape the entire project. The epoxy grout was a gooey, sticky mess to work with, but the tape worked well, and a little vinegar cleaned up the tiles where the tape failed (Figs. 2c & 3).

Hour tiles (e.g. Fig. 4) were affixed with mortar to 4 × 4 inch paving stones, which were then set in at ground level. I found the north-south line with a plumb line at solar noon, and set off the east-west line with a 6-8-10 foot triangle, and the walkway and hour numbers were placed accordingly (Fig. 5).

I have not yet put in Sunrise / Sunset markers. These could be mounted on paving stones, either square or circular.

Fig. 4. Example Hour Markers.

Fig. 5. Hole dug for declination scale with N-S and E-W lines marked.

Fig. 6: Completed Dial

The dial is weathering foot traffic and our summer heat well (Fig. 6). It is set for standard time because the California state legislature has decided not to switch back and forth from Daylight Saving Time in the future. I, like many dialists, await their decision as to what our permanent time will be - PST or PDT.

The sundial has become a popular feature of the garden, especially with school groups. As well as our sign explaining how to use the dial, we will also be incorporating signage explaining how bees use the angle of the sun relative to the hive to navigate and communicate the direction to travel to nectar sources, and back home to the hive. Not only do bees use the fixed angle of the sun while traveling, there is evidence that bees are able to learn the daily pattern of azimuthal movement for their location and time of year. Humans are not the only dialists on the planet!

Rick Williams
timmonswilliams83@gmail.com

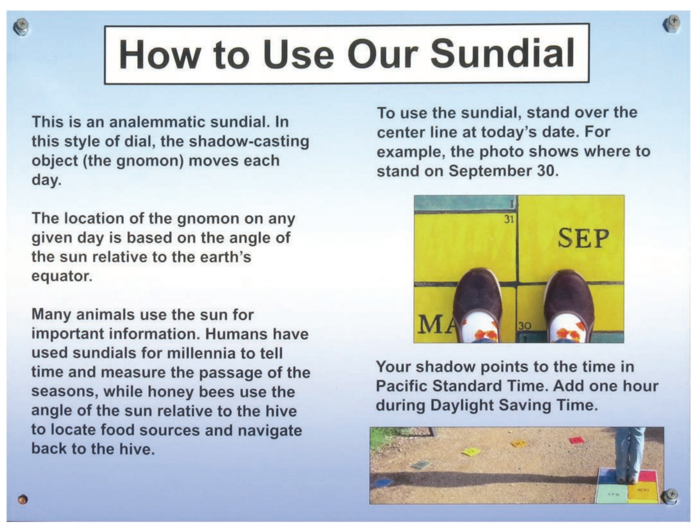

Fig. 7: Instruction Panel

Sundial Sightings: A Close Look at a Vertical Dial

Robert L. Kellogg (Potomac, MD)

Fig. 1. John Hadsall's photo of Joplin Sundial.

Fig. 2. Google Street View of 113 W Third St.

Fig. 3. Google Map of Joplin Sundial.

It's always interesting when someone dips in to the history of a sundial. In downtown Joplin, MO, John Hadsall of the Globe digital edition began probing into the sundial on the face of Ron Jones' Commerce Building at 113 West 3rd St. Hadsall says,

> *I've been enchanted with this sundial ever since I noticed it during a lunch-break walk. I've written before about how I hoof it downtown and find all sorts of treasures under our noses, from the amazing front porches in the North Heights Neighborhood to the brick sidewalks that remain throughout that neighborhood, Murphysburg and other downtown residential areas.*
>
> *The sundial is believed to have always been a part of the more than 100-year-old-building. Originally built in 1904 for a machinery company, it was remodeled into a bus station in 1937.*

Over the years the building was abandoned, finally being purchased by Jones and his business partner Ivan McElwee. Hadsall proceeded to see if the dial told accurate time, taking a photo of the dial and its shadow, Fig. 1, and reporting: "At about 1:05 pm on Thursday [18 July 2019], I took a picture of the sundial at 111 W. Third St... It appeared to be a little behind: the shadow of the gnomon was still crawling toward dead center of the 12."

Of course, the difference between the 12 pm and 1 pm can be chalked up to daylight saving time. But the rest? The photo shows that the sundial itself was cut to face due south (the hours are symmetric and the 6 am – 6 pm line is level). However, the dial's eastern edge is recessed into the wall about 2 inches. For a 12-inch sundial this is nearly a 10° westward angle from the face of the building.

Our forensic search starts after the American Civil War when multiple mining camps sprang up, creating an industry in lead and zinc that lasts to this day. Two camps, Union City and Murphysburg, merged, split, and then merged again in 1873, creating the City of Joplin. At this time the streets of Joplin were laid out in a grid, and as you might suspect, the surveyors used magnetic North, disregarding the offset from true North. (Fig. 2 and Fig. 3).

By using NOAA's website for Historical Magnetic Declination[1], we find that in 1877 magnetic north was 10° East of North (Fig. 4). In 1904, when the Commerce Building was built, the owners decided to mount a dial engraved as true south-facing with symmetric morning and afternoon hour lines. The sundial was recessed on its eastern edge about 2 inches into the wall. This reoriented the sundial by 10° west of the building wall, correcting for the error of the original city planners and placing it true north-south.

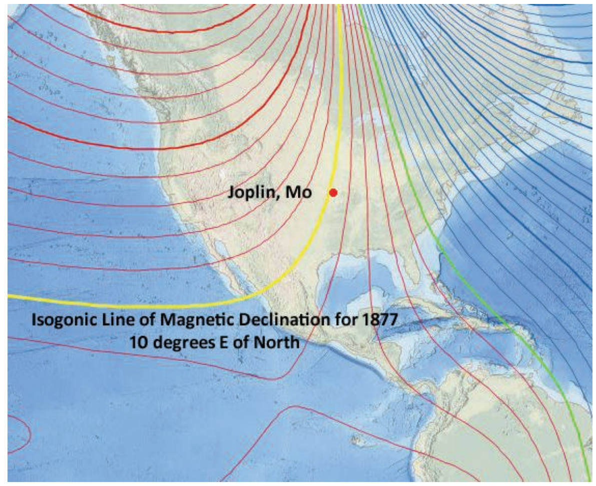

Fig. 4. NOAA Magnetic North – 1877.

What about today? We assume that the hour lines and gnomon are made for Joplin's latitude of 37° 5' N. The longitude of 94° 31' W puts the sundial 4.5° west of the central time zone at 90° W. This means that the sundial's shadow is early by 18 minutes in Joplin, when the sun transits over the central time zone's meridian.

This is only part of the dial's shadow correction required to arrive at civil time. We need to include the sun's Equation of Time, that annual variability between solar and civil time due to the earth's slightly eccentric orbit and 23.4° tilt of its axis. Calculations of the EOT are provided by the British Sundial Society and others, showing that on July 18th the sundial was slow (early to clock time) by 6m 16s. This makes the total difference between sundial time and clock time of 24m 16s. John reported that he photographed the dial at about 1:05 pm. Subtracting 1h 24m gives sundial shadow time of about 11:41 am.

Before estimating the shadow time from the photograph, there is an important feature of the sundial that should be recognized. The concrete gnomon is at least one inch wide, meaning that the western edge of the gnomon is the morning shadow line (trailing edge), and in the afternoon it is the eastern edge of the shadow line (leading edge) that should be read. At 12:00 local solar time there should be two noon hour lines bracketing the gnomon's shadow exactly.

In Fig. 1, we see the number 12 for the noon hour, and no apparent "split" of the hour line. But if we extend the 2, 3, 4, and 5 afternoon hour lines all the way back to the toe of the gnomon, they all meet on the eastern corner (Fig. 5). Eureka! This sundial is properly designed for a thick gnomon. This means that rather than taking the center of the number 12 as noon, we should extend two lines down from the edges of the gnomon and we should measure morning time from the western edge of the shadow.

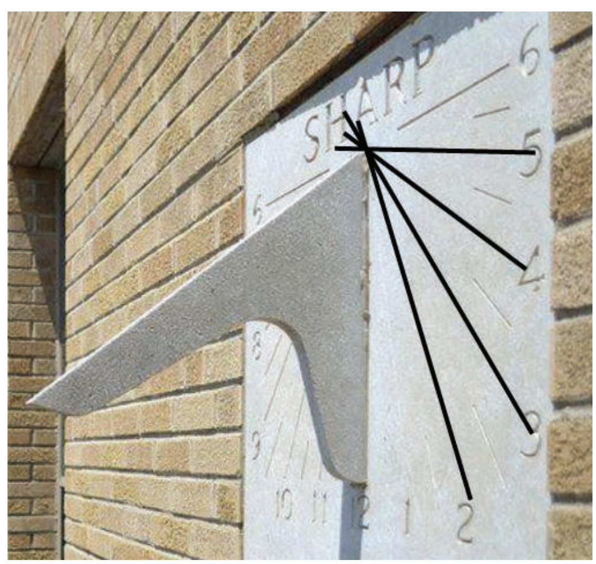

Fig. 5 Converging Hour Lines.

[1] https://maps.ngdc.noaa.gov/viewers/historical_declination/

Fig. 6 Joplin Sundial Shadow Up Close

Now let's take a close look at the photo with two noon lines drawn in (Fig. 6). We see that the shadow edge is only about 10 or 11 minutes past the 11:30 hour line (only seen in the photo as a mere tick). We're able to confirm that the 11:41 solar time (or 1:05 central daylight time) is correct and that this dial is very accurately made and installed.

Bob Kellogg rkellogg@comcast.net

Puzzle: Sabotage

By travelling alone at night, and keeping to goat tracks high above the mountain pass, she had evaded capture and made her way behind enemy lines. Resting during the day, she had walked through three long dark nights. Now, just before the dawn of what promised to be a clear sunny day, the bridge came into view. Her instructions were clear: it was to be blown up in a few hours' time, at 10:30 KMT[1] that very day, September 1, 1926. Precise timing would cause the greatest disruption of the expected enemy attack. She knew that if she failed in her mission, her homeland would be overrun.

The rail line cut deep into the forest here. It was so isolated that even the sound of church bells and factory whistles did not reach this far. There were no buildings nearby, save a ruined chapel near one end of the bridge. She approached cautiously, looking out for sentries. She was safe - the bridge was unguarded and she could work undisturbed to place the explosives. Much relieved, she gathered a few ripe berries and settled down for a brief rest.

As she looked around, her eyes were drawn to a faded sundial on the crumbling wall in front of her. She wondered what her wise professor from the university would have made of it. His fondness for sundials had rubbed off on her, and she had learned enough to recognize an unusual dial – one that showed *only* Italian and Babylonian Hours. Aside from its motto, "Ab hoc momento pendet aeternitas", the only other markings were its year, latitude, and longitude. The nodus and its support were intact, if a little rusty. It had been an elegant and well-made dial; the professor would have liked it.

Suddenly, her thoughts snapped back to her immediate problem. Travelling at night had helped her avoid detection, but in the dark, she had lost her footing more than once. One time she had fallen hard, breaking both her watch and the radiotelegraphy apparatus, and losing her map and compass in the process. Luckily, the heavy pack on her back, filled with dynamite, had not exploded. She had mumbled a word of thanks to Mr. Nobel.

Her challenge now, though, was to know the right moment to detonate the explosives. What could she do?

Send your solution to *nass_secretary@sundials.org*. Just for fun: no prize. Answer in the next issue.

[1] KMT: Kontinenta Meza Tempo, or Continental Mean Time, was a now-defunct time zone used by several neighboring small countries in the early part of the 20th century. For her compatriots, it was a minor point of national pride that the zone meridian passed through their capital city. Everyone knew the longitude in question! Notionally, of course.

Elia Barchetti's Sundial

Armin Denoth (Innsbruck, Austria) and Kurt Descovich (Vienna, Austria)

The Armory of the Tyrolean State Museum hosts a special horizontal sundial with a filament or thread for its polar gnomon, and engraved on a brass plate in a black wooden case.

<u>A short introduction</u>

The dial was donated to the former Tyrolean National Museum in 1837 by "His Excellence the President of the Court Chamber, Friedrich, Earl of Wilczek, for the 'Technological Collection'" [1]. The Earl of Wilczek (1790 – 1861) was an Austrian official and statesman. Among other things, he was the Imperial Governor of Tyrol and Vorarlberg from 1825 until 1837. In this role he campaigned for commercial and social improvements, supporting the university and general education. The southern portion of the dial bears a dedication:

> *A Sua Eccellenza*
> *Federico Conte de Vilczek, Gover. del Tirolo ec. ec.*
> *Il Sac. Elia Barchetti Prof. em.*
> *1827*

The dial had therefore been dedicated by Elia Barchetti, Professor Emeritus, to the district governor of Tyrol, Friedrich, Earl of Wilczek.

Elia Barchetti (July 20, 1781 – June 2, 1856), originally from Rovereto[1], was ordained on March 14, 1812, as a priest [*Sac(erdote)*] of the Diocese of Trent.[2] From 1818 until 1826 he taught mathematics, physics and natural history [2, 3] at the imperial secondary school in Trent. Due to poor health, he retired (hence *Prof[essore] em[erito]*) and also withdrew from the priesthood, but led his *Level IV Grammatical* class (4th year of 6 year secondary school) to completion in 1826 [4].

Subsequently, he calculated and designed the dial (Fig. 1) which he completed in 1827. Its outer dimensions are 37 × 30 × 33 cm. A point of note is that the sundial by Alois Messmer, described in detail in the GSA[3] circular no. 56, Dec. 2018 [5] and in *The Compendium 26-1,* Jan. 2019 [6], features interesting analogies to Barchetti's dial. Both were configured for the latitude of Innsbruck (47°16' N). Both were designed by teachers at former secondary schools, and engraved on a brass plate (Elia Barchetti) or etched on a slate tile (Alois Messmer).

Barchetti's dial indicates Local Apparent Time and Temporal Hours, as well as the Italic and Babylonian Hours mentioned in the inscription (Fig. 11) on the northern part of the sundial:

Orologio solare di principali Popoli antichi e moderni, per la latidunine di gradi 47.16'

Fig.1 The Elia Barchetti sundial.

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[1] In what is now the Trentino-South Tyrol autonomous region of northern Italy. The area has changed hands numerous times throughout history. At the time it was part of the Austrian province of Tyrol.

[2] Also known as Trento (in Italian).

[3] Gnomonicae Societas Austriaca.

It is also possible to read the times of sunrise and sunset hours. The corresponding inscription is on the northern side of the sundial, inside the narrow scale (Fig. 11).

Fig. 2 shows the large number of engraved lines - at first glance somewhat confusing. In subsequent figures we have highlighted some lines and scales for better illustration. We will describe in brief, the different possible readings.

<u>Local Apparent Time</u>

Fig. 3 shows the detail of the gnomon thread with a pinhole nodus pierced through a small disk. The thread's shadow shows the Local Apparent Time (LAT). The dot of light projected by the nodus hole indicates a date around May 15 or July 25, at about 14:20h.

The thread is only used for reading LAT by means of the hour lines shown in Fig. 4. For all other readings the dot of light projected by the nodus hole must be used. To help distinguish them, the LAT lines are marked with the symbol shown here.

The LAT scale spans the right border of the dial from VI (06h) at the top (south) down to IX (9h), then runs along the northern Capricorn hyperbola from X (10h) via XII (12h) to the left end at II (14h), then upwards along the leftmost border of the scale area from III (15h) until VI (18h). The point G is the base point of the pole thread. The inset shows a small part (IV to VI) of the left scale, turned 90°; at the outer border the figure IV for 16h has been engraved in error as VI.

<u>The Compass</u>

Barchetti provided a compass for orientation of the sundial (Fig. 5). The needle has to point to the northern 360° mark ('NORD'). The direction to magnetic north does not match the geographic north which has to be parallel to the edge of the plate; the compass scale is turned by 4.7° to the east, which might have been valid at that time.

<u>Date Lines</u>

Barchetti limited himself to zodiac lines, which in his time were significant due to general interest in astrologic observations.

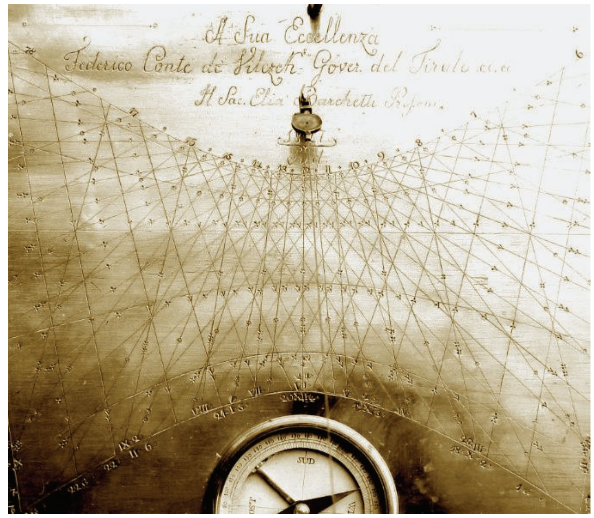


Fig. 2. The many lines of the Barchetti scale plate.

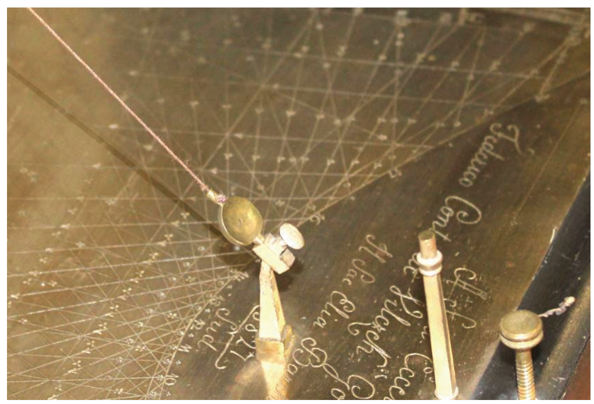


Fig. 3. The pole thread with the hole nodus.

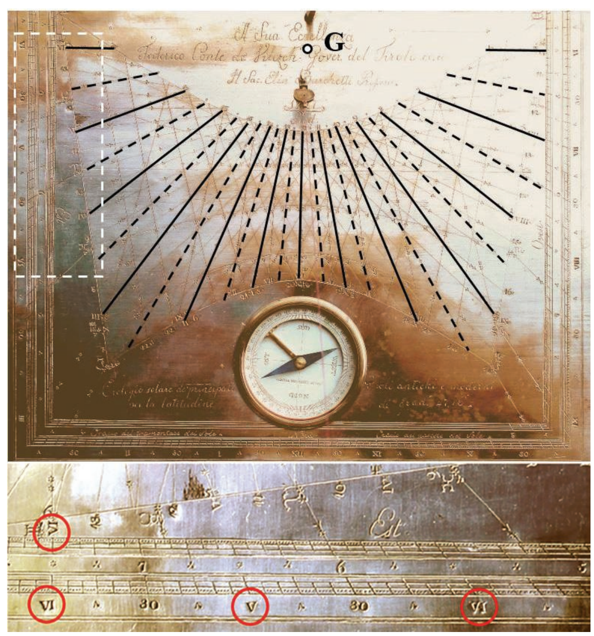


Fig 4. The LAT hour lines (half hours dashed). Inset: detail of the scale.

The end of the lower five zodiac lines (except the upper Cancer and Gemini/Leo lines) are connected by short straight segments to hour scales positioned inside the outer LAT hour scale on the left and right borders. These indicate the sunrise and the sunset hours (Fig. 6). They are engraved "Orario del nascere del Sole" for sunrise and und "Orario del tramontare del Sole" for sunset. For dates between the zodiac transits, these times must be estimated. The inset in fig. 6 shows part of the sunset scale turned 90° counterclockwise; hour labels 6h, 5h, 4h (p.m.) are circled in red.

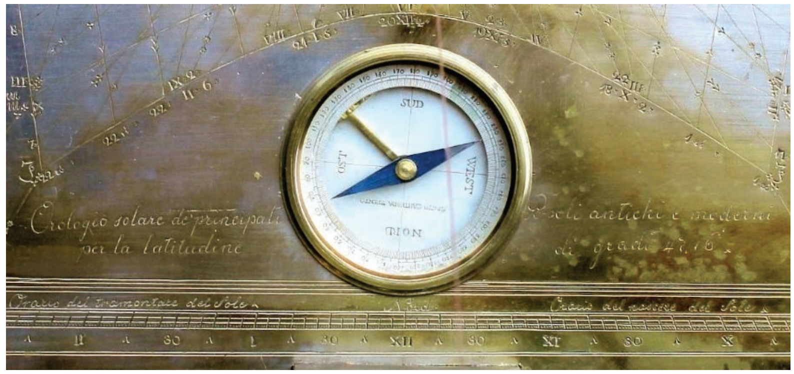
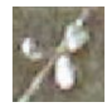


Fig. 5. The Compass, made by Santo Caminado, a business in Trent, is rotated 4.7° east.

Babylonian Lines

As already mentioned, the dial also shows the hours since sunrise (Babylonian) and since the prior sunset (Italic). The Babylonian hour can be read where the light dot projected by the pinhole nodus (fig. 3) hits the Babylonian lines (fig. 7), which are marked with this symbol.



The Babylonian hour scale extends from left top (13:30) to the right border (01:30), see fig. 7. Half hours are dashed, the dashed line second from right is for 01:45.

Italic Lines

The hours since the last sunset are read on the Italic lines (fig. 8) which are identified by the symbol shown here.

Such lines can be found on dials, including Barchetti's, marking the hours since the last sunset; often, however, they are labeled with the difference from 24, hence indicating the hours remaining until the next sunset. On Barchetti's dial the scale extends from top right 09:30 to left 22:30, with dashed lines again indicating the half hours.

Temporal Hours

These "ancient" hours are referred to on Barchetti's dial by the engraved label "Orologio solare di principali Popoli antichi ...".

In Barchetti's detailed description of the dial [7], he states "Ciascuno intervallo delle linee die quest'orolgio esprime in qualunque tempo dell'anno la duodecima parte del tempo, che il sole rimane sull'orizzonte".

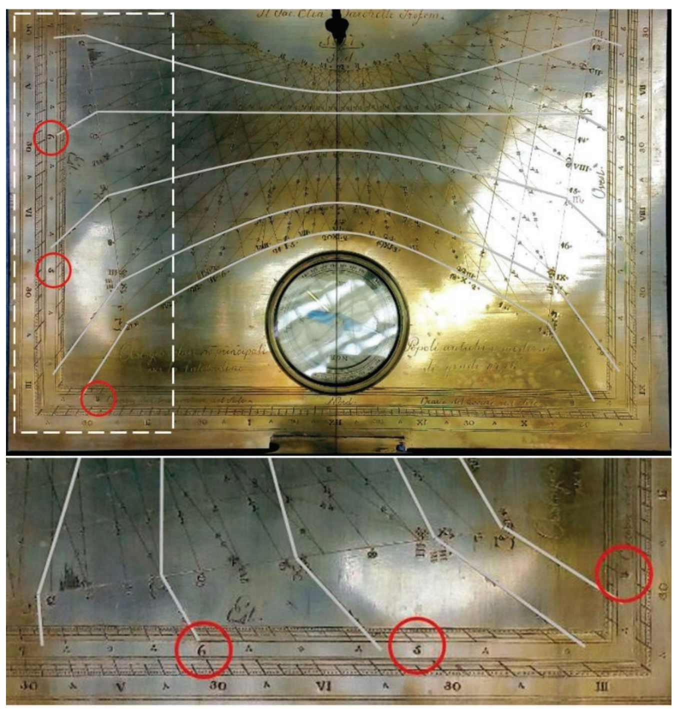


Fig. 6. The five "northern" Zodiac lines with their extensions to the sunrise and sunset hour scales. Inset: detail of dashed area.

They are the Temporal hours which divide the light day from sunrise to sunset into 12 equal parts; they are short during winter and long during summer (fig. 9).

The Temporal hour scale is engraved along the (lower) Capricorn zodiac line. The hours are indicated with roman numerals from bottom right (II, III) to bottom left (X). See fig. 10.

Barchetti marked the Temporal lines with the symbol shown here.

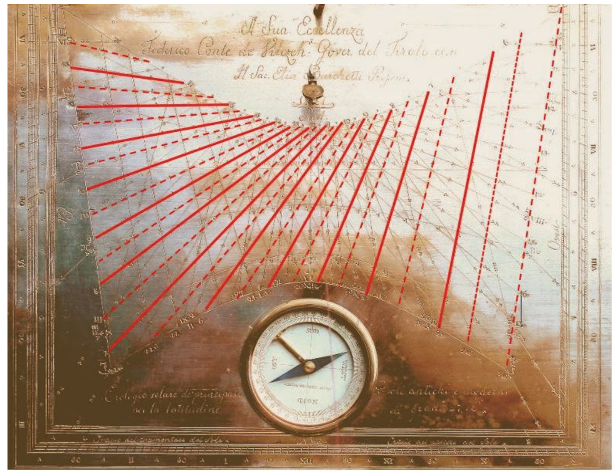


Fig. 7 Babylonian hour lines.

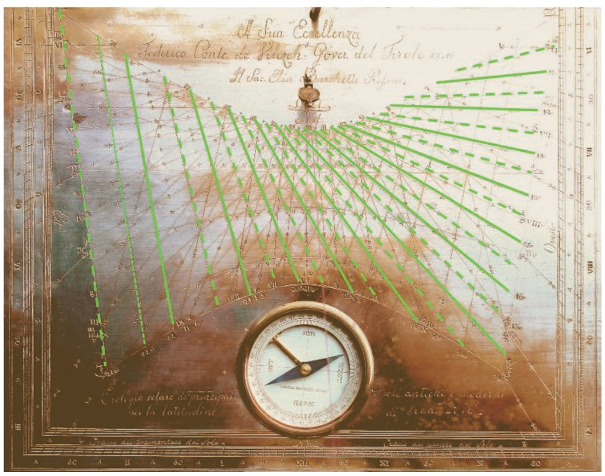


Fig. 8. Italic hour lines.

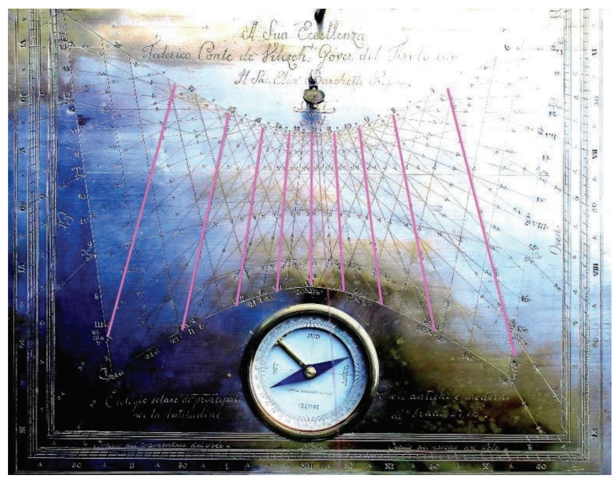


Fig. 9. Temporal hour lines.

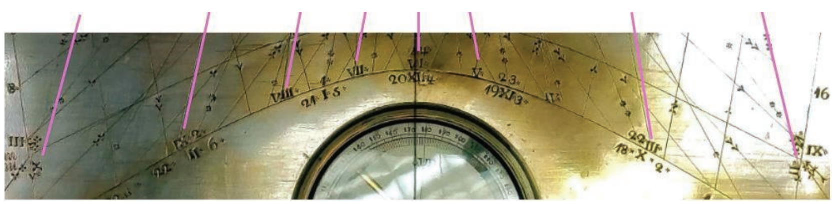


Fig. 10 The Temporal hour scale inside the lower Capricorn zodiac line.

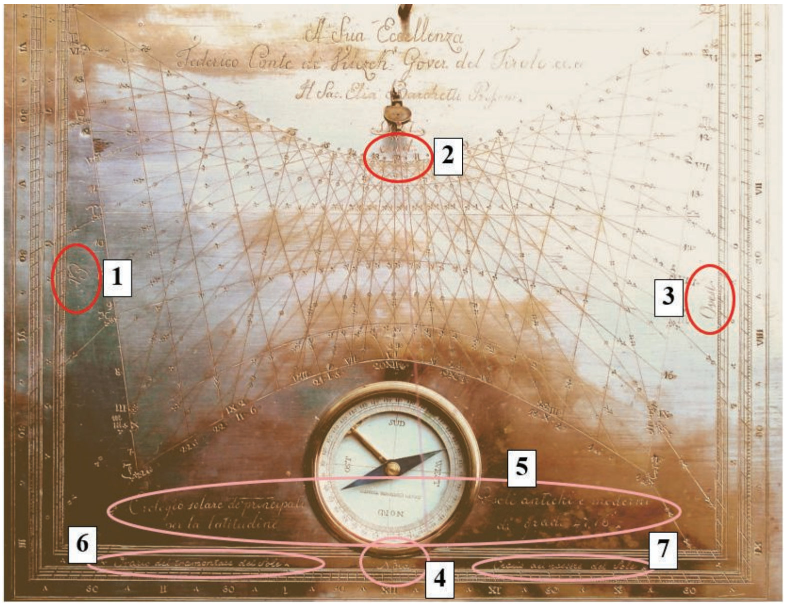
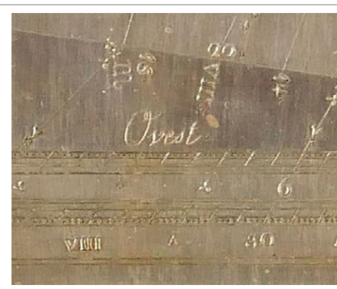
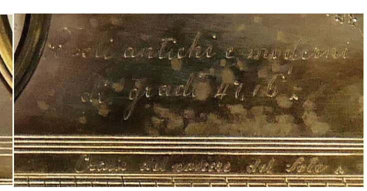


Fig. 11. Inscriptions.

Fig. 11 shows some inscriptions, listed below for completeness.

1	Est (East)	
2	Sud (South)	
3	Ovest (West)	
4	Nord (North)	
5	*Orologio solare dei principali Popoli antichi e moderni per la latidunie di gradi 47.16'* (Sundial of the most important ancient and modern peoples for the latitude 47°16').	 
6	*Orario del tramontare del Sole* (sunset hour)	
7	*Orario del nascere del Sole* (sunrise hour)	

We have therefore a dial in front of us that really has it all! Whether or not the dedicatee, the Earl of Wilczek, knew how to use it, is an open question. We do however respect the intellectual effort and practical experience that Elia Barchetti put into this little instrument.

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Kurt Descovich *kd-teletec@medek.at*

Sources

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[2] Il Messagere Tirolese Nr. 71, Roveredo, Venerdì 4 Settembre 1818.

[3] Schematismen der Provinz Tirol und Vorarlberg, 1819 ... 1826.

[4] Cataloghi del Clero, Archivio Diocesano Tridentino: Mitteilung vom Archivar Dott. C. Andreolli.

[5] A. Denoth und K. Descovich, 2018. Alois Messmers analemmatische Sonnenuhr. Sonne+Zeit Nr.56, 2018.

[6] A. Denoth and K. Descovich, 2019. Alois Messmer's Analemmatic Sundial. The Compendium 29(1), March 2019.

[7] E. Barchetti, 1827, Descrizione ed uso dell' orologio solare. Bibliothek TLM-Ferdinandeum, Sig. W5028/4.

Photo credits: The sundial is held at the Tiroler Landesmuseum Ferdinandeum (TLMF), Historische Sammlungen. Catalogue number AK/U/309. The Fig.1 photo is courtesy of TLMF. All other photos are by Armin Denoth.

Time of Our Lives: Sundials of the Adler Planetarium

Reviewed by Hal Brandmaier

Sara J. Schechner's *Time of Our lives: Sundials of the Adler Planetarium* has recently been published and is available for a reasonable price. It is the third volume of the series *Historic Scientific Instruments of the Adler Planetarium*. Volumes 1 and 2 catalogued the Adler's collection of astrolabes.

This magnificent 449-page new volume, encased in a colorful dust jacket, is about 10½″ × 11½″ × 1½″ and weighs about 5 lbs. It contains 268 sundials, categorized and fully described by Sara.

After a 'Foreword' and 'A Note on the History of the Adler's Collection' by two Adler staff, Sara takes over with a chapter on 'Time Finding and Social Change' and one on 'Time Finding versus Timekeeping'. Time finding includes sun and moon dials, while time keeping includes calendars and clocks.

Next, 'The Guide to the Catalogue' helps the reader locate specific sundials of interest and what information is available for each sundial in the catalogue. There are many divisions including more than 30 Butterfield-type sundials and over 80 Multiple Faced Sundials. The book concludes with many interesting appendices including a glossary, bibliography and credits.

Of particular interest to me are the shadow-caster designs, the noon cannons and the ivory Diptych Sundials. On another note, I was able to trace my Butterfield-type dial as being made by Lasnier, with dial number 93 in Sara's list identified as being made by '*Lanier*'. Sara suggests "Lanier might be an error in engraving". The Adler's polyhedral dials are described by Sara as "Rube Goldberg machines".

With its detailed descriptions, explanatory definitions and detailed photographs, it is a superb reference book for anyone interested in sundials.

Hal Brandmaier *hal2dial@gmail.com*

[ISBN: 978-0-578-49710-5; $40 USD, plus tax and shipping, from https://shop.adlerplanetarium.org]

Sundial Photo Competition 2020

We are launching a sundial-themed photography competition, open to all NASS members. Artistic, illustrative, documentary, humorous … anything goes. The only condition is that photographs must show in a fairly prominent way, a sundial, nocturnal, astrolabe, or similar artifact closely related to dialing - but it doesn't have to be the only subject.

A judging panel appointed by the NASS Executive will select a shortlist of photos for display at the 2020 NASS conference in Philadelphia. Conference delegates will vote for their favorites; the photograph receiving the most votes will win. Winning and runner-up entries will be printed in *The Compendium* and displayed on the NASS website. The winner will receive a one-year extension of their current NASS membership.

Other requirements

The photographs may be created by digital photography or by film photography. In either case, entries are to be submitted digitally. Any file format will be accepted if we are able to process it; if not, you will be asked to convert your file.

Although entries must be submitted electronically, for final judging we will print them on glossy paper. The photos will be resized (scaled) to fit on Letter size paper with a minimum 1″ border. You should select your photo and image resolution accordingly.

As well as conventional images, we welcome entries that involve techniques such as pin-hole photography, long exposure, time-lapse, etc.

Submit your photograph by email to nass_secretary@sundials.org. Be sure to state:

- the title or caption of the photograph,
- the place, date and time of the photograph,
- your name as you wish it to be displayed,
- optionally, a brief note or description.

The deadline for entries is midnight, June 30, 2020 in your time zone. We will accept up to 3 entries per person (please submit each entry as a separate email).

By participating in the competition, you grant NASS the non-exclusive right to reproduce your photograph. You also agree to us keeping it indefinitely for potential future use on our website, in *The Compendium* and in other publications or materials produced by NASS.

As well, for any recognizable people in your photograph, you must obtain a 'release' (see example below). Each release must indicate that the person (or parent of a minor) agrees to their image potentially being featured on the NASS website, in the NASS journal - *The Compendium* - and in other NASS publications. Submit a scan or other digital copy of the release(s) with your entry.

For inquiries, contact nass_secretary@sundials.org.

PHOTOGRAPHY SUBJECT RELEASE

I, [PRINT YOUR NAME], grant the North American Sundial Society (NASS) permission to publish, whether now or in the future, the photograph of me taken on [DATE] by [PRINT THE PHOTOGRAPHER'S NAME]. This permission extends to any NASS publication whether print, digital or online, including the NASS website.

Signature [YOUR SIGNATURE] Date [DATE]
Co-signature of parent/guardian if minor [SIGNATURE] Date [DATE]

3-D Design and Printing Sundials, Part 1

Bill Gottesman (Burlington, Vermont)

This is the first of a series of brief *Compendium* articles by various contributors on using software and 3-D printers to develop skills and techniques to design and print your own sundials. The availability and affordability of 3-D printers and of inexpensive on-line printing services, have created wonderful opportunities for developing and sharing sundial designs.

Our sundialing community has already seen some examples of this technology. Bob Kellogg wrote about creating a miniature replica of the Schmoyer Sunquest sundial in the December 2017 *Compendium*, and you can buy this fully functional 3-D printed model on the NASS website. At the 2019 NASS conference Steve Lelievre demonstrated a full-size 3-D printed example of Fred Sawyer's new Polar Envelope Gnomon sundial, complete with a complexly shaped gnomon and a rotating chapter ring for Equation of Time correction (see the article on p.5 of this issue and the illustration on the front cover). Bob Kellogg and I 3-D printed the gifts for the 2016 and 2019 NASS conferences respectively, with each gift customized for the attendee's latitude via code written into our design software. These examples demonstrate the versatility, power, convenience and precision of this technology.

This first article will focus on preliminaries: Selecting a 3-D design software and options for printing. There are three steps required to create a printed object:

1) Design the object with a software program you are comfortable using,

2) Convert your 3-D software image into a file that tells your printer the specific mechanical instructions it needs to build your object layer-by-layer, and

3) Print your object in the material of your choice.

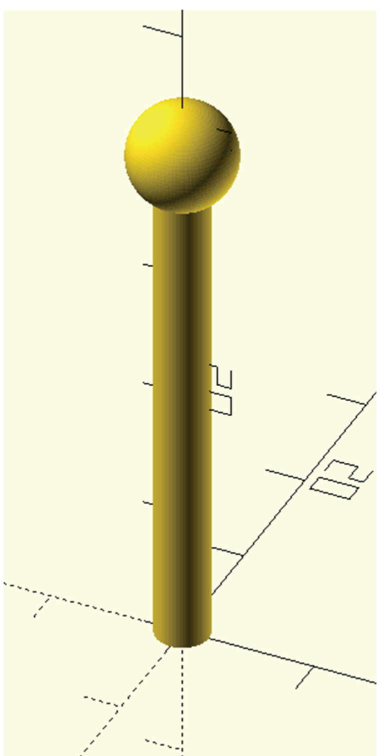


Fig. 1. Stylus gnomon created by OpenSCAD code example.

There are a very large number of software programs available for designing 3-D objects. Among the most popular are Google's Sketch-Up, Fusion 360 and Rhino3D. I have tried to learn these three and eventually gave up due to a steep learning curve and feeling overwhelmed by features I would likely never use. I eventually settled on a free program called OpenSCAD which has many advantages that will appeal to sundial designers and is what Bob Kellogg and Steve Lelievre settled on as well. It works on Macs and PCs and is available at www.openscad.org.

OpenSCAD (pronounced "open ess-cad") creates its 3-D objects completely from computer coded instructions written line-by-line by the user. This creates objects with mathematical precision, essential for sundials. The language will feel familiar to people who know how to program and is not too difficult for inexperienced coders like myself. There are very few buttons/mouse movements to learn, which was a huge relief to me after trying the prior 3-D software packages. The on-line reference manual has plenty of commented examples of code (see wikibooks.org/wiki/OpenSCAD_User_Manual). People have posted a huge number of files of OpenSCAD creations at www.thingiverse.com, free to download and try out, and often with well commented code. In this *Compendium* series, we will teach an introduction to OpenSCAD, creating various dials and techniques along the way. Files of code for teaching examples and for some finished dials, will be available at the NASS website www.sundials.org.

For example, a simple gnomon tower (Fig. 1) might be coded like this in OpenSCAD (with comments):

```
// All comments are green and are preceded by "//".
// All commands are in blue and end with a semi-colon. There are just 3 commands here.
// The next line is a command.  It draws a cylinder with radius 2 and height 40.
cylinder(r=2, h=40);
// The next two lines draw a ball with radius 4, translated (moved) to
// the top of the cylinder, which is at 3-D coordinates x=0, y=0, z=40).
translate([0, 0, 40]) sphere(r=4);
// This next instruction sets the facet number (resolution) of the drawing
//to a high level, with 90 facets (flat surfaces) to a complete revolution
//of a cylinder or sphere.  Low values make the images look clunky.
//High resolutions look great but make the program run slower and
//create a large file when sent to the printer.
$fn = 90;
```

Figure 2 shows the OpenSCAD window. The left box is the editor, where all code goes. The right side shows the drawing area and a console whose messages are very useful for debugging. Pressing F5 (function key 5 on the keyboard) creates a quick preview of the object specified by the code. Pressing F6 creates a more precise and complete image, ready for export to a stereolithographic file for printing, but takes more computing time.

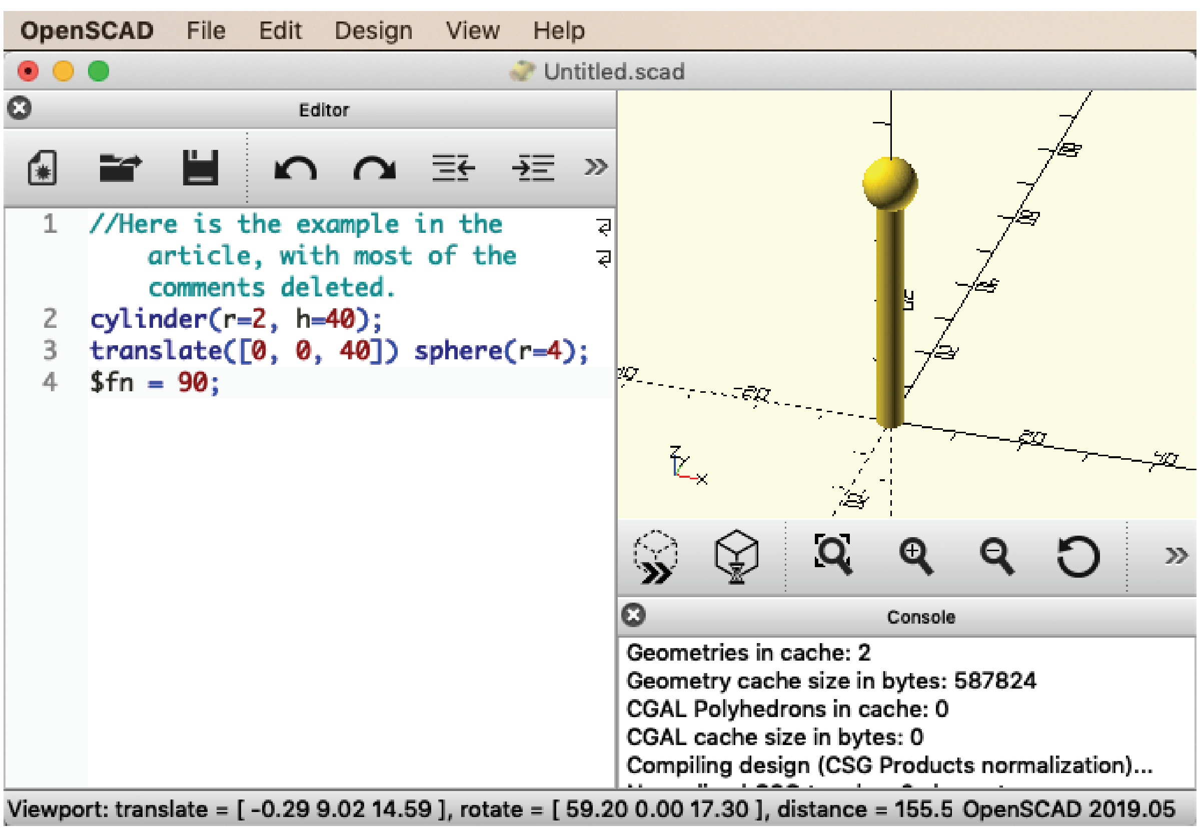


Fig. 2. OpenSCAD window.

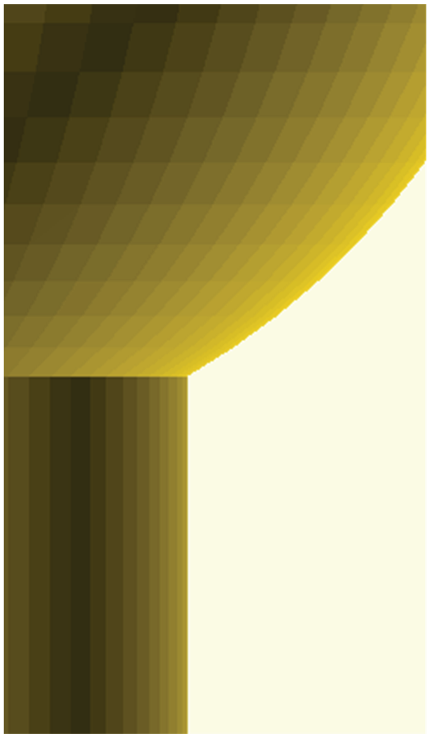


Fig. 3. Close up of tessellated planes of .stl file.

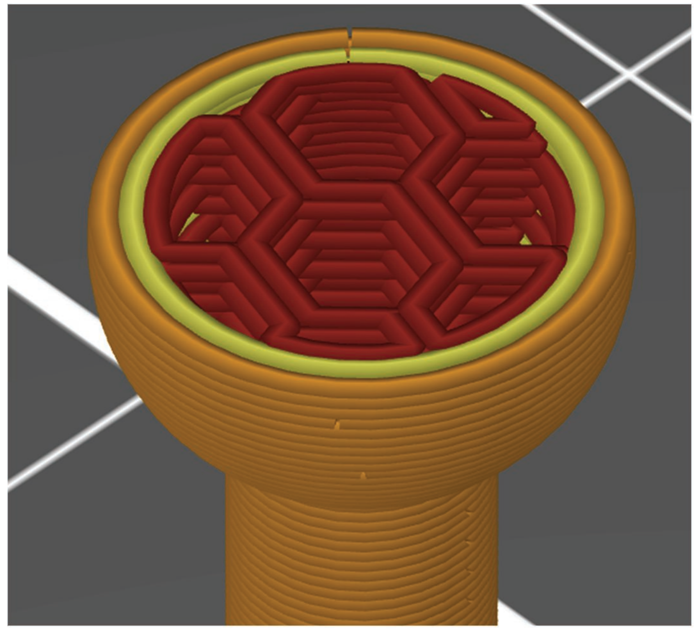


Fig. 4. Sliced section of gnomon. The printer will be given commands in g-code to create these patterns of extruded plastic. The colors shown here do not indicate the color of the material used – they represent various parts of the object: infill (red), inner wall (green) and outer wall (brown). Note how in order to save material, there are voids in the infill. Image is from Slic3r.

All 3-D design programs, including OpenSCAD, store their files in a format that is easy for that particular program to draw and manipulate, but these files are not printer friendly. However, 3-D design programs do export their creation into file formats which can be printed. These are stereolithographic (.stl) files, in which the object to be printed is constructed from very many tessellated planes (Figure 3).

Some printers can print directly from an .stl file, but most printers need to print from a specific set of numerical commands, called g-code, that tell the printer exactly how to move the print head, how much plastic to extrude and at what temperature, etcetera[1]. An intermediary software program, called a slicer, is needed to turn the .stl file into g-code for your printer (Fig. 4). A popular (and free) slicing program is Slic3r, which we will utilize in this series of articles.

If you do not own a 3-D printer, there are many on-line services that will create a print for you from your .stl file. Some can even print in steel or bronze, rather than plastic. There are too many service providers to mention, but I have had good experiences using www.shapeways.com (they operate in many countries worldwide).

The next article in this series will build on programming skills using OpenSCAD to design a basic sundial.

Lastly, if you would like to contribute to this series of 3-D design articles, please contact Compendium editor Steve Lelievre (via nass_secretary@sundials.org).

Bill Gottesman *billgottesman@comcast.net*

[1] Most consumer 3D printers build up an object by combining many thin layers formed from a bead of extruded plastic, but other approaches can be used: for example, laser sintering of powdered material, and UV-triggered hardening of liquid resins. As well, the .stl file can be converted into a control file for shaping an item by CNC milling.

Addendum

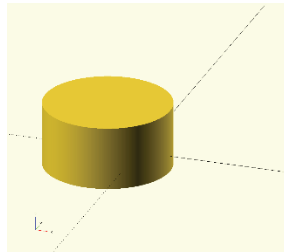
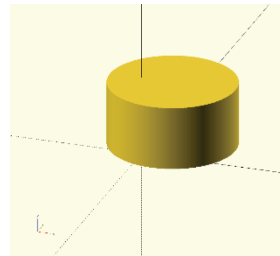
Before we design our first simple sundial, in the Part 2 article, it is worth taking a minute to review a basic principle of 3D modelling: complex models are constructed by combining simpler component objects using the principle known as Boolean Combination. As well as merging shapes into one, it can involve taking away parts of a shape. Here is a summary using the pertinent OpenSCAD commands.

The cylinder shown here on the left, L, is positioned slightly left and down from the origin. It is defined by

```
translate([-10, 0, -5]) cylinder(r = 20, h = 20);    // L
```

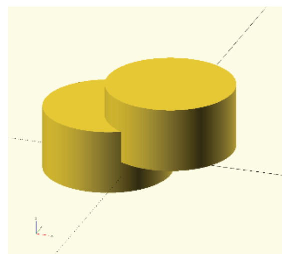
The one shown on the right, R, is positioned slightly to the right and up from the origin. It is defined by

```
translate([10, 0, 5]) cylinder(r = 20, h = 20);      // R
```

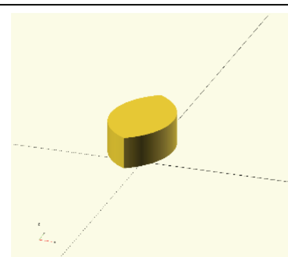
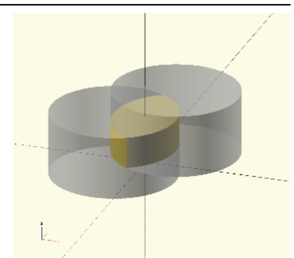
Now suppose we want to treat L and R as a single object in any further processing. We need a **union** of the two objects: everything that is part of either L **or** R.

```
union() {
  translate([-10, 0, -5]) cylinder(r = 20, h = 20);    // L
  translate([10, 0, 5]) cylinder(r = 20, h = 20);      // R
}
```



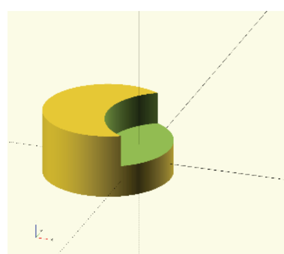
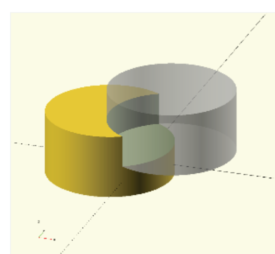
Next, let us consider an **intersection**. The resulting object is the overlap: the small shape that belongs to both L **and** R.

```
intersection() {
  translate([-10, 0, -5]) cylinder(r = 20, h = 20);    // L
  translate([10, 0, 5]) cylinder(r = 20, h = 20);      // R
}
```

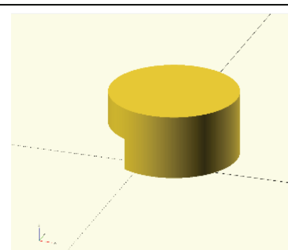
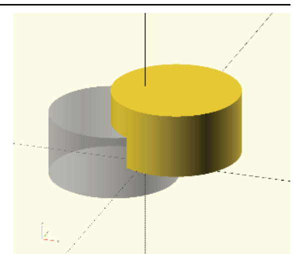
Lastly, the **difference** operation. Unlike the previous cases, the order that you list the component objects is important. If we list L first, the resulting object keeps only the parts of L that are not also parts of R. In Boolean logic, it is L **not** R. In Set Theory, it would be the **complement of R in L**.

```
difference() {
  translate([-10, 0, -5]) cylinder(r = 20, h = 20);    // L
  translate([10, 0, 5]) cylinder(r = 20, h = 20);      // R
}
```

By listing R first, the resulting object has only the parts of R that are not also parts of L. It is R **not** L, the **complement of L in R**.

```
difference() {
  translate([10, 0, 5]) cylinder(r = 20, h = 20);      // R
  translate([-10, 0, -5]) cylinder(r = 20, h = 20);    // L
}
```

Steve Lelievre steve.lelievre.canada@gmail.com

The Podere Terravera Sundial

Silvio Magnani (Milano, Italy)

The *Podere Terravera* mural sundial (44° 57′ 59″ North, 9° 25′ 27″ East) is located at a country estate near Piacenza in northern Italy, about 50 Km south of Milano. The wall bearing the mural faces southeast; the angle between the perpendicular and south, the declination of the wall, is 56° 20′ (Fig. 1).

The sundial has two quadrants in order to represent the four seasons separately. They are actually two sundials, the first one for Summer and Autumn and the second one for Winter and Spring. Each of the two sundials has its own stylus or time indicator located at its top near the eave.

I chose the colors to represent the seasons of the year: green for spring, yellow for summer, brown for autumn and blue for winter.

I calculated the layout with the help of software written by Ing. Gianni Ferrari. The gnomon was constructed to my design by a mechanical workshop, and I had the assistance of a professional painter for transferring my design to the wall. This was done by printing the finished layout at full size on numerous sheets of paper which we applied to the wall so that the layout could be traced.

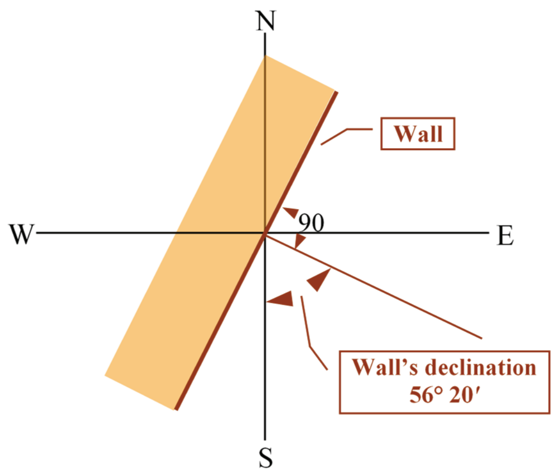


Fig.1. Wall orientation.

Podere Terravera.

Functioning

The wall of the sundial is illuminated by the sun in the morning hours, while it is in the shade in the afternoon. The stylus casts its shadow on the sundial surface; the shadow at the end of the stylus indicates the time in the morning.

At the end of the stylus there is also a small circular mirror, whose vertical surface is oriented west. When the sun reaches its southern peak, the wall is almost completely in the shade, while the small mirror begins to be hit by the sun. The reflected light of the mirror is projected onto the wall in the shade, creating a small light spot, which is the time indicator in the afternoon.

The sundial is designed so that the morning hour lines coincide with those of the afternoon; the 11:00 line becomes the 13:00 line in the afternoon, whereas the 10:00 line becomes the 14:00 line, and so on. In the morning, until around noon, the time is read by looking at the shadow of the end of the stylus; then the shadow will be replaced by the light spot.

Description of the sundial

Noon and local solar time

The local solar noon is the instant in which the sun reaches the local meridian, the meridian of Podere Terraverra. The sun is then exactly south and daylength, from sunrise to sunset, is divided into two equal parts; the time from dawn is therefore equal to the time to sunset.

Figure 2 shows the solar noon lines for Podere Terrravera indicated by M1 for the sundial quadrant that covers Summer and Autumn and by M2 for the quadrant that covers Winter and Spring. The straight vertical line is the true meridian. A1 and A2 indicate the other solar hours for the two quadrants.

The hour lines are numbered 5, 6, 7, 8, 9, 10 and 11 from top to bottom (those of the second quadrant are partially covered by the first quadrant) and 13, 14, 15, 16, 17, 18, 19, in lighter color, from bottom to top. The same hour lines are used both in the morning and in the afternoon.

Fig. 2. The dial. M1 and M2 indicate the local meridians, apparent noon. Line sets A1 and A2 are other hour lines.

Central European Mean Time (TMEC)

TMEC is the time system used in central Europe and hence in Italy; it is the time marked by our watch. The time measured by our watch (mean time) differs from the local (true solar) time in two respects:

1. The speed of the earth, which follows an elliptical orbit around the sun, is not constant during the year. By the laws of physics, its speed is greater in some parts of the year and less in others. This phenomenon determines a variable length of the solar day during the year. Instead, our watch ticks at a constant speed; and this is why solar and mean watch time differ. This difference is called the Equation of Time. Figure 3 shows the Equation of Time through the year.

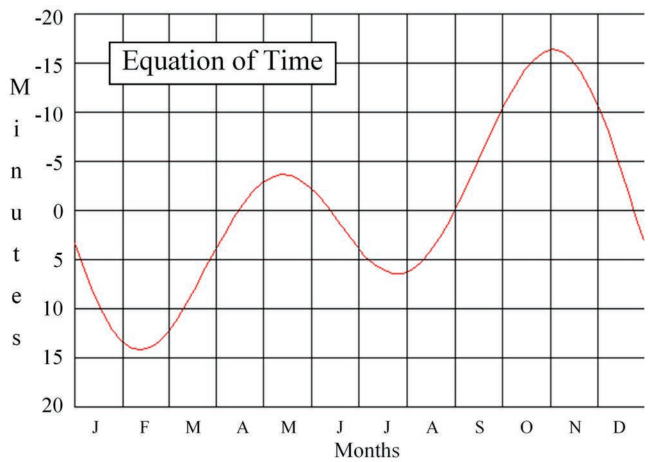


Fig. 3. The Equation of Time

2. We have seen that the solar time for Podere Terravera is synchronized with its meridian (9° 25′ 27″ east of Greenwich) whereas watch time is synchronized Central European Mean Time meridian (15° east of Greenwich). The difference in longitude between the two meridians is: 5° 34′ 33″. The sun - travelling at 1° in 4 minutes, or 24 hours for an entire 360° revolution - takes 22 minutes and 18 seconds to move from the Central European meridian to the local meridian. I shall call this the Longitude Constant for Podere Terravera.

To calculate the TMEC, it is necessary to subtract the Equation of Time from the local solar hour and add the Longitude Constant for Podere Terravera. A graph drawn on the wall (Fig. 4) facilitates this calculation by showing the difference between TMEC and local solar time. It is simply a matter of adding the minutes indicated by the curve for the relevant date, to obtain watch time.

The TMEC 12:00 (12:00h by a watch) curves are reported on the two quadrants of the sundial. A direct reading of 12:00 mean time is therefore possible. Figure 5 shows the dial's 12:00 curves, marked B1 and B2, relating to the Summer/Autumn and Winter/Spring quadrants.

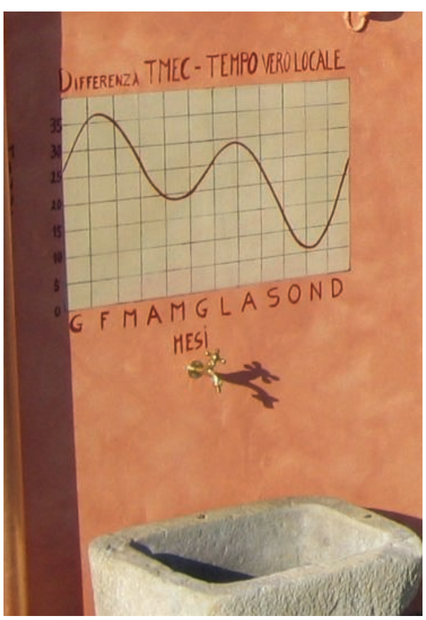


Fig. 4. The Equation of Time graph drawn on the dial.

Fig.5. TMEC 12:00h lines, indicated by B1 and B2.

Solstices and Equinoxes

Figure 6 shows the summer solstice (Ss) and the winter solstice (Sw), both on the first and the second quadrant. The autumn equinox (Ea) is indicated on the first quadrant, while the vernal or spring equinox (Ev) is indicated on the second quadrant.

Fig. 6. The solstice, equinox and zodiacal month lines.

In addition to solstices and equinoxes, the lines that mark the passage of the sun from one constellation to the next (C1 and C2) are also indicated. The symbols of the various constellations are painted between one line and the next. In winter: Capricorn ♑, Aquarius ♒, Pisces ♓. In Spring: Aries ♈, Taurus ♉, Gemini ♊. In Summer: Cancer ♋, Leo ♌, Virgo ♍. In Autumn: Libra ♎, Scorpio ♏, Sagittarius ♐.

Reading the sundial

As already mentioned above, the quadrants of the sundial are illuminated by the sun in the morning but shaded in the afternoon.

When the quadrants are illuminated by the sun, the time is indicated by a 'shadow spot', generated by the hemisphere-shaped end of the stylus; when the quadrants are in the shade, the time is indicated by a 'light spot' reflected from a small circular mirror, applied to the flat face of the hemisphere at the end of the stylus.

Figure 7 shows one of the styli; the end of the stylus, where the mirror is applied, is indicated by an arrow.

Fig. 7. The shadow caster / mirror combination and close view (inset).

Fig. 8. Shadow of the stylus.

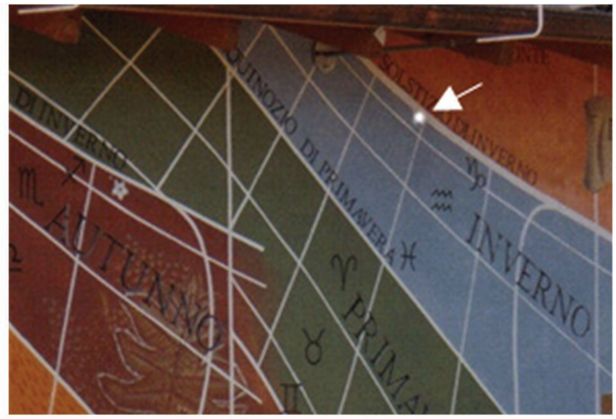


Fig. 9. Light spot from the mirror.

The photos in Figures 8 and 9, taken a few days after the winter solstice, show the shadow of the stylus a few minutes before 11:00 and the light spot reflected from the mirror right after 14:00, respectively. In both figures, the time is read just below the solstice line, which had been reached on December 21. Arrows indicate the position of the shadow spot and the light spot.

The light spot retraces, from right to left, the same line already followed, from left to right, by the shadow spot in the morning.

After the winter solstice, with the sun getting higher and higher in the sky, the shadow and light spots move lower and lower on the sundial until the summer solstice, when they start rising again during summer and autumn.

Fig. 10. Shadow spot direction of travel.

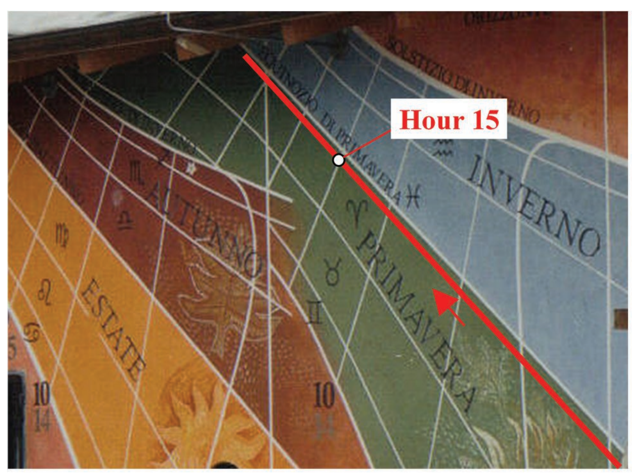


Fig. 11. Light spot direction of travel.

Figures 10 and 11 show the path of the shadow spot and the light spot, respectively, on March 25, some days after the beginning of Spring. The shadow spot marks 11:00, while the light spot marks 15:00.

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[Editor's note: For a more detailed technical description of the functioning of this dial, see: Ferrari, G., "Sundials With A Double System To Show The Hours" in The Compendium, 13(4), Dec. 2006, pp. 27 - 34. An article covering related concepts may also be of interest: Ferrari, G., "Reflection Sundial With A Shadowing Rod" in The Compendium, 14(2), June 2007, pp. 32 -36.]

An Unexpected Problem

Don Petrie (Stouffville, Ontario)

[*Editor's note: I asked Don Petrie to prepare this short report describing how the Christ Church dial, with its innovative use of a new engineered material, fared over its first decade. I would welcome "then and now" comparisons for other dials.*]

Fig. 1. The dial in 2007.

It has been over ten years since the Christ Church Sundial was constructed and installed [1, 2]. At the time, 2007, it was the first sundial made from high density urethane (HDU) and I am unaware of any other sundial that has been made using this material since then.

HDU is created by a chemical foaming process that creates an internal structure with millions of tiny cells that are mostly separated from each other. The closed cell structure makes it completely waterproof and therefore well suited for outdoor applications. Although lightweight, it is remarkably strong and rigid, and does not warp or bow. It is durable, rot proof, crack resistant and can withstand extremes of heat and cold. It is easily machined and can be worked with regular wood-working tools. After coating with ordinary exterior paint, it becomes maintenance free [3].

All these features should make HDU an ideal material for making sundials. So, how do these claims stand up for the Christ Church dial after 12 years? The answer is "very well." There has been some insignificant fading of the paint when compared directly with the original colors. The dial has had no need for routine maintenance since its installation. Compare Figs. 1 and 3.

One repair has been necessary: in 2014, seven years after the dial's installation, a small hole appeared on its face. This slowly enlarged and it became apparent that the hole was completely through the dial. Soon some material began protruding from it, and it was determined that a squirrel had somehow built a nest in the narrow gap between the wall and the dial (Fig. 2. left). The squirrel had tried to increase its space by chewing and destroying a larger chunk of material from the back. The hole in front was just the "tip of the iceberg". The dial was lowered and removed to my garage for management of this catastrophe.

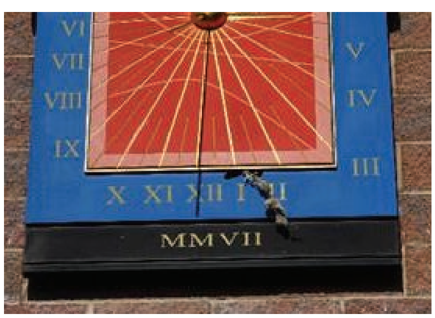


Fig. 2. The dial in 2014. Left: Squirrel entering nest via hole in face of dial. Right: Detail of the damage.

I was able to easily cut out the damaged section (Fig. 2, right) of the dial face with a scroller saber saw. Fortunately, I had kept a few pieces of HDU of matching thickness that were left over from the original construction. I cut a new piece to fit and glued it in place. I then sealed the seams with epoxy resin and sanded the surface smooth. Three coats of an exterior type of paint to match the original blue paint and the front of the dial looked like new.

Fig. 3. Sept. 21, 2019. The nodus shadow is almost on the equinox declination line.

I filled the chewed-out space on the dial's back with an epoxy paste and stapled a layer of galvanized ½″ metal mesh over the back of the whole dial. This so-called "hardware cloth" was readily obtained from our local hardware store and should protect the dial from any similar damage in the future.

This repair was the only maintenance our sundial has received during its twelve years of its existence. It confirms the manufacturers' claims as indicated above, thus HDU seems to be a suitable material for the making of sundials by those dialists not fortunate enough to be able to use more traditional materials such as brass, bronze or stone.

Don Petrie
don.petrie@sympatico.ca

References

[1] D. Petrie. (2008). [Presentation]. NASS Annual Conference, St. Louis, 2008.
[2] D. Petrie. (2009, June). *Development Of The Christ Church Sundial*. The Compendium, 16(2).
[3] Sign Arts Products Corp. (n.d.). *Signfoam*. Available at http://www.signfoam.com.

Overhead view of a sundial in a turning circle, Lexington, KY

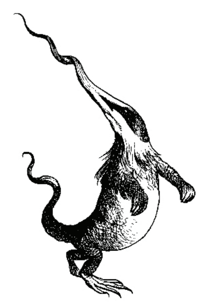
NASS Registry Entry #606

Digital Bonus

This issue's Digital Bonus includes:

- The new version of François Blateyron's *Shadows* program for Windows PCs. The free version allows you to lay out several common types of dial and related diagrams. You can buy a license key to unlock access to the full suite. The Bonus consists of the installer for version 4.4 build 8338 (64-bit) and the installation guide (English). The software is configurable for a number of languages.
- Powerpoint slides from Fred Sawyer's presentation at the 2019 NASS conference introducing his Polar Envelope design – the noteworthy innovation described in his article in this issue, p.5.
- A video in MP4 showing a 3D printer in operation as it produces a Sawyer Polar Envelope dial. Note that the design shown was a prototype that does not match the illustrations used on the cover of this issue and throughout the article.
- A stereolithographic model (STL file) of a Sawyer Polar Envelope Dial donated by Jeff Kretsch to the Turner Farm Observatory in Great Falls, VA. If your computer does not have a facility for viewing STL format files, you could use an online viewer instead. The service at https://3dviewer.net/ does an adequate job.

The Tove's Nest



A watch with an interesting treatment of the Equation of Time

See https://quillandpad.com/2018/04/24/equation-of-time-what-is-it-and-whats-the-attraction-in-a-watch/ and in particular, the illustration for the *Greubel Forsey Quantième Perpétuel à Équation* (via Bill Gottesman).

Kevin Karney has created a very helpful animation for understanding the mechanism. See https://youtu.be/hs4Jt44x6Pw (via Fred Sawyer).

In Memoriam

We are sad to report the death at age 102, of Irving Isaacson, our oldest member.

His autobiography, *Memoirs of An Amateur Spy,* recounted his experiences in Europe in the period immediately after World War II. He had been a U.S. Army soldier assigned to the Office of Strategic Services, with action behind enemy lines supporting the Dutch Resistance. After demobilization, Irving chose to stay on in Europe at his own expense and at his own initiative. Frequenting bars and cafes, he used his affable nature and competence in several languages to get to know senior army officers of various nationalities – all the while gathering intelligence about the activities of Soviet forces in Eastern Europe.

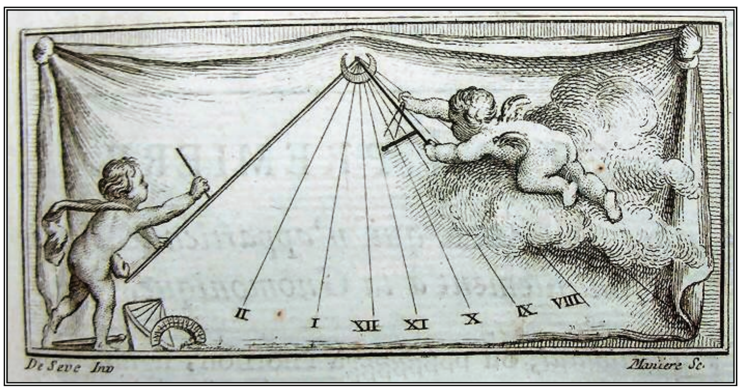
It was during this period that he met his wife, Auschwitz concentration camp survivor Judith Magyar Isaacson (d. 2015). Eventually they settled in Lewiston, Maine, where he practiced law, she became an educator of note, and together they raised a family of 3 children.

Irving joined NASS in 2006. His sundial-making activities developed from another recreational pursuit: he was a gifted metalsmith and artist, producing works in iron, brass and copper.

[Prepared using information drawn from www.brannlaw.com, www.sunjournal.com and www.pressherald.com.]

The Blaylock Mansion, Nelson, British Columbia

NASS Registry Entry 966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